ILLUMINATING ENGINEERING

JULY 1951

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Special Problems in Chemical Plant Lighting
Lighting Projection Screen Surroundings
Cause of Humidity Effect in F-Lamps
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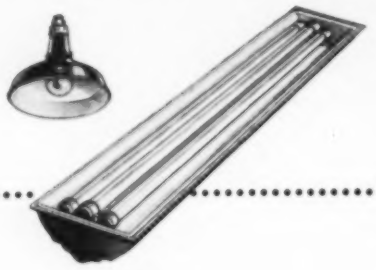

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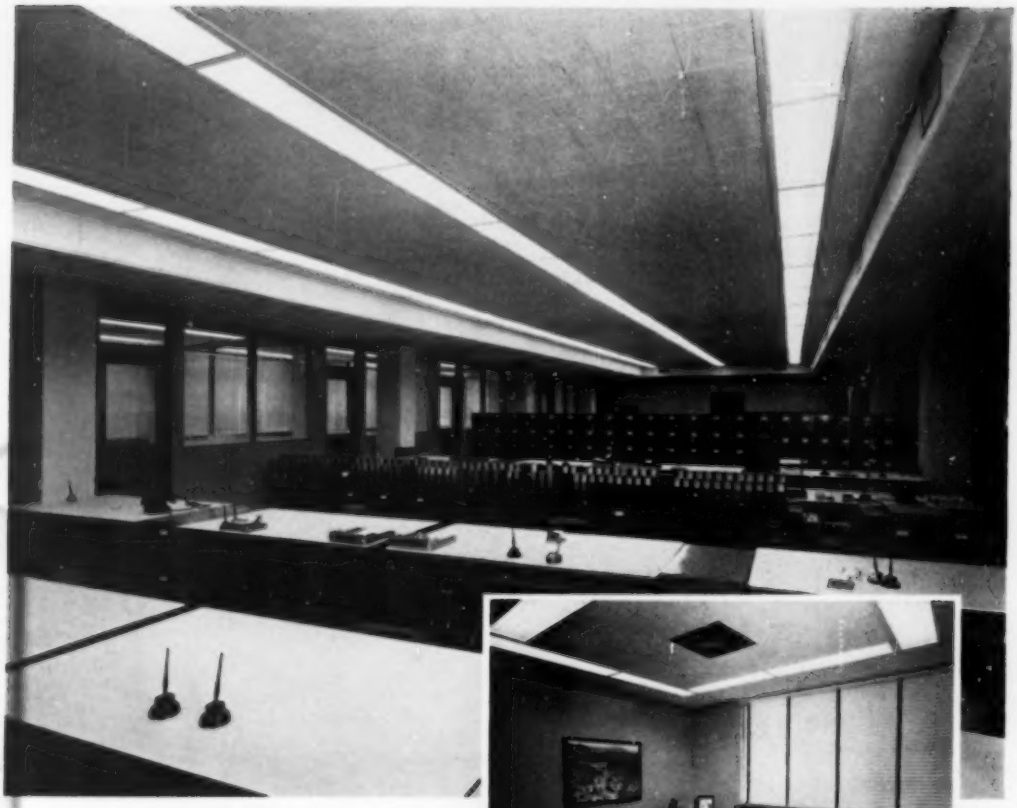

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Special Problems in Lighting a Chemical Plant — Joseph H. Snow — 329
A More Precise Method of Computing Zonal Lumens — David A. Toenjes — 335
Illumination of a Laboratory Table — Ludvig C. Larson — 338
Lighting the Boeing Stratocruiser — R. J. Helberg — 340
The Cause of the Humidity Effect in Fluorescent Lamps — Robert H. McFarland — 345
Twenty Years of Nighttime Sports — 350
Lighting Data Sheet—Series XVI
Lighting a Billboard (23-5) — 352
Recent Developments in Visual Low-Approach and Landing Aids for Aircraft — Maurice A. Garbell — 353
Lighting Data Sheet—Series XVI
Lighting a Hallway (22-28) — 359
Lighting Projection Screen Surroundings — James R. Cravath — 361
Sequence-Start Series Ballasts for Instant-Start Fluorescent Lamps — Hans U. Hjermstad — 365
I.E.S. Research for Defense — A. F. Wakefield — 373
The Functional Visual Activities in the Home and the Location and Extent of the Associated Areas to be Illuminated — 375
TELECAST—Lighting News of Current Interest — 5A
Lighting Calendar, 7A; It Seems to Me, 16A; Obituary, 17A; Books and Pamphlets, 17A; New I.E.S. Officers, 17A; Installations to See in Washington, D. C., 17A; New Members, 20A
Short Application Item—
Three-Way Approach to Comfort for Industrial Area, Rockford, Ill., 374
I.E.S. Publications — 4A, 27A, 28A
Index to Advertisers — 32A
I.E.S. Conference — 33A

Sustaining Members — For latest listing of Sustaining Members, refer to April 1951 issue of ILLUMINATING ENGINEERING, page 14A.

◆

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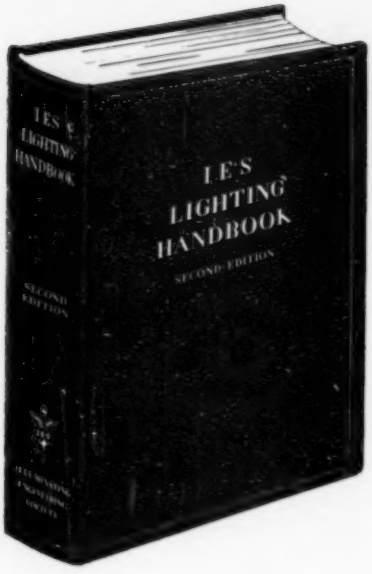

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Special Problems In Lighting A Chemical Plant

By JOSEPH H. SNOW

Chemical plant lighting includes all the problems of general industrial lighting, plus many problems peculiar especially to the chemical and refining industries. This paper does not attempt to go into these general problems and applications but rather describes lighting methods used in the Freeport, Texas chemical plant and discusses special problems and applications peculiar to the industry.

MANY CONDITIONS are imposed on lighting in chemical plants, which require considerable study on the part of the designing engineer. Corrosion and hazardous gases, for instance, are two of the more serious problems, imposing stringent requirements on lighting equipment. Equipment must be selected that will meet these conditions.

Outdoor lighting is a phase of industrial lighting that is often neglected, especially in peacetime, but good exterior lighting is an essential part of chemical plant lighting design. Adequate illumination should be provided for all roadways, passageways, fences, loading areas, parking areas, and other points of outdoor activity, or where protection from intruders is desired. Area lighting is also of the utmost importance in case of fire, explosions, or other emergencies, which, of course, are quite possible in chemical plants and refineries where unstable products are handled.

At the Freeport plant, vapor-proof floodlights mounted on self-supporting steel towers approximately 100 feet high are considered the most economical and advantageous method, although street lighting equipment could be considered. Both narrow and wide beam with plain and diffusing lens are used. Water towers are also used to support these floodlights where available. This installation provides a minimum of 0.25 footcandle of illumination over our entire plant, except remote areas. Glare is reduced to a minimum by the mounting height of the floodlights, and lighting is more evenly distributed over the entire areas, including roof tops of buildings as well as process plant structures. This, of course, offers good coverage against intruders as well as facilitating detection of any unusual conditions that may occur. Also by mounting floodlights at this height, considerable contamination and corrosion was eliminated which otherwise would have increased maintenance difficulties.

Author: Engineering Department, Texas Division, The Dow Chemical Co., Freeport, Texas.

Power plant turbine floor has high-bay deep-bowl open type 750W reflectors and incandescent lamps. Turbines are white with orange trim. Floors are gray.

Where buildings and structures are close together, local vapor-proof or explosion-proof luminaires mounted on brackets at doors or hung from structures, pipe-supports, etc., are satisfactory.

Of course, there are some disadvantages in area floodlighting over, say a streetlighting system, primary of which are the long shadows cast by tall buildings and process plant structures. Fog or escaping vapors also hinder visibility to a greater extent than would have been encountered with lighting equipment mounted at lower elevations.

The lighting of process plants may be broadly divided between lighting of building interiors and lighting of exterior equipment and facilities, such as towers, tanks, boilers, evaporators, walkways, etc. The illumination requirements within these two categories are extremely varied. Luminaires, wiring devices and wiring material must be selected to meet the illumination and electrical requirements of the plant and likewise must be suitable for use in the atmosphere of the area under consideration from a standpoint of moisture, vapors, corrosion, hazardous gases or other factors which would govern equipment, material and construction.

In general, we may classify atmospheric conditions of any particular area within our plant as

(1) Areas which are normally clean and dry (a condition seldom approached on the Gulf Coast).

(2) Areas where dampness and vapors are present, but not hazardous or particularly corrosive.

(3) Areas having exceedingly corrosive conditions.

(4) Areas where explosive gas or vapor concentrations may occur.

Illumination requirements, however, depend on the seeing tasks. The quality and quantity of light should be the same for identical seeing tasks no matter what atmospheric conditions are involved. The application problem for luminaires, then, is to select equipment that will provide the desired illumination and be of a type suitable for use under the particular atmospheric condition encountered. The requirements which lighting equipment must meet under these various atmospheric conditions will be discussed later, but first let us take up the various application problems from an illumination standpoint, considering first lighting within the interior of plant buildings.

Interior Lighting

Types of general lighting used in the interior of our process plants are not different from normal practice for other industrial plants with similar seeing tasks. Briefly, luminaires which concentrate the light in a relatively narrow beam are desirable for lighting buildings with high bays and narrow interiors. Where the building is relatively wide, equipment with a wide distribution may be used effectively to provide a greater overlapping of light beams with a resultant reduction in shadow intensity and with higher vertical surface illumination. Likewise, wide angle distribution type luminaires are required to produce uniform illumination at low mounting heights. Luminaires, which do not produce a wide distribution, must be more closely spaced to avoid spotty lighting. Most general lighting within our plant buildings falls within the latter two categories, and for this reason,

lighting fixtures with standard open industrial type porcelain reflectors are commonly used.

Normally a symmetrical layout of luminaires with uniform mounting height is desirable. Many plant buildings have equipment of such a nature, or so located, that luminaires must be positioned with specific reference to the working or seeing points. Where a uniform intensity throughout the areas is not essential, such a positioning of lighting equipment provides a high level at the critical point, and at the same time provides sufficient illumination for adjacent areas. In addition, nonsymmetrical layouts are often required in order to avoid interference with piping and equipment, to eliminate objectionable shadows and to provide more ready access to the units for relamping. In connection with relamping, it is desirable that luminaires not be located over open tanks, open bus bars, dangerous equipment or other points which would make relamping hazardous.

Supplementary lighting must be provided at many points in the process plant. Gages, valves, push buttons, and other control points should always receive sufficient light to enable quick and accurate operation. Liquid column gages are usually illuminated by special gage light units mounted either in front or in back of the gage glass. Angle type reflectors are frequently utilized for illuminating individual instruments and gages and vertical surfaces of equipment. Special-purpose units are sometimes installed in the top of vessels so that the interior may be easily inspected. In such installations it is, of course, necessary that special precautions be taken so that contents of the vessel will not damage or escape through the luminaire. Special lighting equipment is often provided for the illumination of the inside of filters or other equipment whose operation must be inspected through observation ports. If the equipment does not include built-in luminaires, concentrating type reflector luminaires would be mounted at ports in the equipment housing. Instrument panels which contain indicating recording pyrometers, flow controllers, gages, level indicators, etc., are usually located in separate control rooms and require supplementary illumination on the vertical surface. Luminaires should be located directly in front of and above the instrument boards in such a manner as to minimize specular reflections from the instrument windows in the observer's field of view. For this purpose, angle type elliptical reflectors for use with incandescent lamps and angle reflectors for fluorescent luminaires are frequently used. Recently, fixtures using refracting glass lens have been used to provide more uniform illumination of control boards with less glare.

Exterior Lighting

Much of the equipment and many control points of our process plants are located outdoors. This requires considerable lighting since operators must inspect, maintain, and operate this equipment at all times. There are many stairways, platforms and ladders involved, and frequently operators and maintenance personnel must ascend towers and structures to elevated points in order to perform their duties. The safety of the personnel as well as the proper operation and maintenance of the equip-

Compressor building is lighted with 500-watt explosion-proof luminaires with dome reflectors. Note flexible hangers for luminaire alignment and vibration insulation.

Top level lighting of chemical plant superstructure. Floodlights for area lighting are vaportight and are mounted on structural steel standards for illumination of walkways.

Walkway lighting standards consist of 200-watt vaportight luminaires mounted on supports which are galvanized after fabrication. Installations of the same type are used at pumping stations.

ment demands adequate lighting.

Area lighting from tower floodlights provides general over-all illumination, but this is insufficient for usual access to and operation of this outdoor equipment. The design engineer, therefore, must locate luminaires suitable for the atmospheric conditions involved at all points where additional illumination is needed. It is especially important that all elevated platforms, stairways and ladders be well lighted. If possible, luminaires should be shielded from the direct view of personnel using these facilities and should provide uniform illumination. On unobstructed platforms, 150-watt incandescent lamps spaced on 12- to 18-foot centers have been found adequate. Rather than depend on conduit for support of the luminaire for platform or passageway lights, we now use angle iron vertical support with the unit bolted to a welded bracket. Our old method was to support the unit by means of 1¼-inch conduit, which also carried the lighting circuit. Excessive corrosive conditions caused the conduit to rust from the inside, which could not be painted, and eventually the stanchion would collapse. By using angle steel, all surfaces of the support are exposed to maintenance painting and conduit can be replaced when required without disturbing the luminaire.

Vapor-proof or explosion-proof luminaires are used for all outdoor installations. The units are usually of cast iron or cast aluminum construction with a protective alloy coating and clear glass globe. Reflectors are not used except above top platform or ladder tops since it is usually desirable to illuminate in all directions where there is a complexity of piping, equipment and structures. This helps to mitigate shadows and provide better over-all illumination of outdoor installations.

Portable luminaires are frequently used for inspection and maintenance work in chemical plants. Explosion-proof or vapor-proof types, depending on the atmospheric condition involved, with 50-foot portable cables are connected at industrial receptacles near manholes or towers, tanks and other locations. Receptacles should be located at many convenient points within the process plant in order that portable lamps, power tools and blower fans may be readily used.

Emergency lighting, both fixed and portable, is desirable in many areas within chemical plants. Wherever a power failure would create a critical situation involving the safety of men and equipment, an emergency lighting system supplied by battery or an automatic starting power unit should receive careful consideration. In one of our electrolytic process plants where corrosive conditions are severe, we have recently installed an emergency lighting system using 6-volt sealed beam automobile headlights supplied from storage batteries. The sealed beam headlamps were used because of the corrosive conditions there, and of course required a special mounting board. This system is very effective and dependable. In other

For tank car loading rack, 300-watt R-40 reflector floods in weatherproof holders are furnished with a heat-resistant glass not subject to breakage from impingement. Light can easily be directed to any area.

areas we have 115-volt emergency systems where a source of battery power is available, such as in our power plant. We are now engineering another emergency light installation which will utilize an automatic starting gas engine power unit and luminaires with wide spread refracting glass globes. The use of standby power units for emergency lighting is probably not as dependable as the use of a battery system but the initial cost for an equivalent system is considerably less.

Recently, we equipped two trailers with gasoline engine power units and portable floodlights for use under emergency conditions or where a readily available source of light is required for construction purposes. Mounted on the trailer, these floodlights may be aimed in any direction. They are equipped with 50-foot cords so that the floodlights may be removed from the trailer and used at more advantageous locations. Several other small power units are also used, equipped with floodlights and extension cords, for easy access to any area where an emergency source of light is required.

Corrosion Problems

Corrosion is probably our most serious problem. Even though some areas are relatively free of corrosion from chemical vapors, sea coast locations with a salt atmosphere means that corrosion resistance is an important consideration in selecting equipment, no matter how free the area may be from chemical contamination.

In areas which are reasonably clean and dry, such as shops and boiler rooms, standard open type industrial reflectors are most often used for general and localized illumination. Where lower brightness and better diffusion are desirable, the glassteel diffuser type luminaire is used. Fluorescent lighting has been restricted to offices and electrical control rooms, primarily due to its vulnerability to corrosive atmosphere.

Vapor-proof lighting is essential in most of our non-hazardous production plants where considerable dampness and vapors are present. Vapor-proof units which stand up well under corrosive conditions are essential in most cases. A cast iron alloy enclosure with a cadmium-zinc-aluminum protective coating offers fairly good resistance to corrosion. We have experienced some difficulty with rust building up between the threads of the enclosure and the glass globe, which may crack the glass or interfere with relamping. This can be avoided to some extent by coating the threads with a rust preventative compound of soft consistency before screwing in the globe. Painted steel reflectors, which were supplied in place of porcelain enameled steel during the war, are definitely undesirable due to the rapid rate of deterioration. Porcelain enamel reflectors stand up fairly well, but as soon as a chip occurs, spreading rust will soon render the reflector completely useless.

Many areas within our plant have an exceedingly corrosive atmosphere, which requires special technique in the lighting installations. This condition

In areas of excessive corrosion, 300-watt R-40 reflector flood lamps are furnished with porcelain sockets. Note use of open wiring on cleats attached to wooden roof decking. This uses a minimum amount of metals.

occurs primarily in electrolytic production plants where various corrosive elements are present in considerable concentrations. Unfortunately, the type of corrosive element present varies considerably from area to area. For instance, chlorine will cause an acid condition in the presence of moisture, which will corrode most metals. Caustic also has a deteriorating effect on most metals. However, it has been found that metals which stand up well under chlorine conditions will not necessarily stand up under caustic conditions, and vice-versa. The selection of lighting equipment, utilizing metal which will resist the type of corrosive action involved, therefore becomes complex. In most applications where corrosion is particularly severe, we try to avoid the use of metals as much as possible. Open wiring with type TW insulated conductors supported by porcelain cleats is used wherever possible. Conduit is used to suspend units and for drops to switches and receptacles because of the necessity for mechanical protection and strength; however, it is frequently necessary to replace conduit in such installations. Consideration is being given to rigid plastic conduit for this application. Bolts, nuts, and screws should be made of monel or bronze or other corrosion-resistant metals. For general lighting, we have found that the R-40 sealed reflector lamps of 300- and 500-watt sizes give good results, primarily due to there being no possibility of reflector corrosion. Porcelain lamp sockets are used and are attached directly to structural members wherever possible. This gives us a lighting system with a minimum amount of metals which may corrode. Corrosion of lamp socket threads, which has caused us some difficulty in this type of installation, can be controlled by use of silicone grease, which also facilitates removal of lamps.

In one of our electrolytic plants, corrosion has been so severe that it was necessary to move part of the wiring to an outside location with taps of neoprene jacketed cord running to the lighting outlets. In this case, the cord was terminated in an ordinary weather-proof compound socket with a bare bulb. The lip of the socket fits snugly around the bulb, which excludes most corrosive gases from the metal parts of the socket and bulb. Of course, this is a poor lighting installation from an illumination standpoint due to the poor distribution and glare, but under the conditions it is about the best we have been able to do.

Many areas in refineries and chemical plants are classified as hazardous due to the possibility of explosive gases and vapors being ignited by an electric spark. Lighting equipment and fittings must be of a type approved for these conditions and must be installed to meet the NEC requirements. Practically all the equipment in use at the present time is of the type which will confine such an explosion to the conduit system. The theory in this instance is that explosive gases will enter the conduit system through the many joints, or when the system is open for servicing.

Flexible luminaire supports are used in practically all cases where explosion-proof light fixtures are pendent mounted. These flexible supports provide for vertical suspension of the unit and absorb most vibration that may be present.

As in vapor-proof lighting, care must be used in selecting equipment that will not easily corrode. Breathers and drains used to prevent condensation within equipment should be of monel metal. These must also be checked periodically to see that they do not become stopped up with foreign material.

Space prevents discussion here of a number of the other problems native to chemical plant lighting, such as maintenance procedures and electrical systems. It has been our purpose in this paper to encourage a better understanding of some of the design problems peculiar to this industry.

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A More Precise Method Of Computing Zonal Lumens

By DAVID A. TOENJES

LIGHT output of a lamp or luminaire can be determined in two ways. It can be placed inside a sphere photometer; the reading integrates the light output, at all angles. The second method — which must be used if the light output is to be found for only a certain angular cone — is calculation of the light output from the candlepower-distribution curve or data. This second method is the one to be discussed here.

A set of factors, known as zonal constants, is commonly used to compute the lumens in each zone from the corresponding candlepower values. In the interests of simplicity, the usual assumption has been that the candlepower at the center of each zone is a representative value for the zone as a whole. The mid-zone candlepower value has therefore been multiplied by the constant to determine lumens in the zone.

The above assumption, applied to the broad candlepower distributions that are characteristic of most sources for general lighting, has been fairly valid. But now we are finding an increasing use of downlighting and other special applications, involving the design and use of light sources with narrower beams. With such sources, the conventional method of computing lumens often leads to errors too large to be neglected.

Two errors are inherent in the conventional zonal-constants method; they can be reduced only by resorting to smaller and smaller zone intervals in the computations. The first cause of error is that a single selected candlepower value at the midpoint of a zone is seldom the average for the zone. The second cause of error is the changing ratio of lumens to candlepower, at different angles within a zone. This change has its effect within even a relatively narrow interval — especially when such a zone is close to the photometric axis (0° or 180°). This is borne out by the fact that zonal constants show more variation near 0° and 180° than they do near 90°.

The changing ratio of lumens to candlepower can be explained with the help of the drawing, Fig. 1. If a sphere of a unit radius is constructed around a small light source as a center, all the luminous flux will fall upon the inside surface of the sphere. It can be seen that candlepower values directed at angles between 0° and 1° will illuminate only a small circle upon the sphere's surface, while at the same time, candlepower values at angles between 9° and 10° will illuminate a ring of much larger area, as shown. This indicates that the ratio of lumens to candlepower increases with the angle from the axis, and that this ratio's change may be significant even for fairly small intervals.

A new method, outlined herein, corrects for both of these factors and achieves considerably better accuracy for the amount of computation involved. This is indicated in Table I, which is based on the 0°-10° zone of a typical candlepower distribution curve, in this case a curve for a 150-watt R-40 reflector spotlamp (Fig. 2).

Comparison

The most exact method for computing lumens — and the most time-consuming — is that of graphical integration of the area beneath the candlepower-

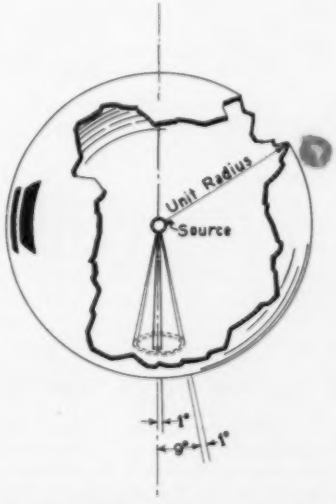


Figure 1. Relative effects of luminous flux at different angles from a light source.

Author: Engineering Division, Lamp Department, General Electric Co., Cleveland, Ohio.

TABLE I.—Summary of Methods Used and Accuracies Obtained.
(Based on Curves in Figure 2)

Selection of the cp values used	Intervals in 0°-10° zone	Computed Lumens in the zone	Error, based upon the most precise method	Method makes possibility that the selected ordinates may vary widely from the true average cp	correction for changing ratio of lumens to candlepower at different angles within each zone
Integration beneath curve	Ten	452	——	yes	yes
At midpoint of zone	One	544	20% high	no	no
Average within zone	"	528	17% high	yes	no
At angle "b" of formula	"	429	5% low	no	yes
Computed from formula	"	452	*	yes	yes
At midpoints of zones	Two	469	4% high	no	no
Averages within zones	"	469	4% high	yes	no
At angles "b" of formula	"	444	2% low	no	yes
Computed from formula	"	452	*	yes	yes

*Error is within the limits of accuracy of plotting the curve used and reading candlepower values from it. Such limits in this case are judged to be approximately ½ of 1%.

distribution curve. For this purpose, the curve first is plotted on rectangular coordinates, and then multiplied point-by-point by the varying sine of the angle, to convert it to an area which is proportional to lumens (based on the equation $d\phi = 2\pi I \sin\theta\, d\theta$). The integration can be made as precise as desired, within the limits of graphical accuracy.

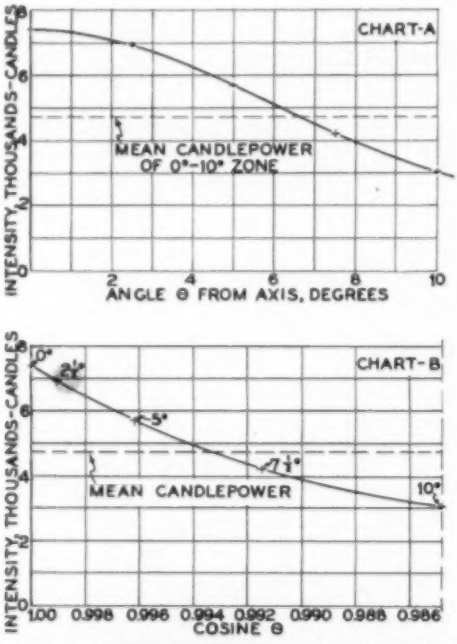


Figure 2. Candlepower distribution of a 150-watt R-40 reflector spotlamp, plotted in Chart A on the usual equal-angle scale, and in Chart B on a scale proportional to solid angles or area. In Chart B the mean candlepower is the average height of the curve, since lumens are proportional to area.

The conventional zonal-constants method has the inherent errors already mentioned. Applied to the typical curve for the 150-watt R-40 reflector spotlamp, it shows an error of 20 per cent with a single 10-degree interval and 4 per cent when two 5-degree intervals are used.

Modifying this method slightly, and substituting the computed average (or arithmetical mean) value of candlepower within the interval, the accuracy can be improved slightly. By this method, variations in candlepower within the zone are taken into account. However, the method is still fundamentally an approximation. The slight gain in accuracy would not ordinarily justify the amount of work, which is roughly tripled.

Next can be considered an approximation which, while using a single reading within each interval, chooses it at an angle which takes into account the second source of error in the conventional method — the variation in the ratio of lumens to candlepower, at different angles within the zone. The appropriate revised angle for each interval is given in Table II, as angle "*b*." Thus no more computation is required than by the conventional method, but there is an improvement in accuracy, error of 5 per cent *vs* 20 per cent for the single 10-degree interval in this case, and 2 percent *vs* 4 per cent for the 5-degree intervals.

Finally, using the new method in its entirety, one of the errors is made negligible and the other eliminated. In this case the results agree exactly with those obtained by integration. Computation of lumens involves three steps instead of one, but they are simple and certain short-cuts can be effected. For comparison, more intervals may be used with the conventional method until it requires the same amount of work as the new method with a single larger interval. The conventional method then still falls short of the accuracy obtained by the new method.

TABLE II.—Constants Applying to Formulas Below.

Zone	a	b	c	k_z
0°- 5°	0°	3.50°	5°	0.0239
5 - 10	5	7.90	10	0.0715
10 - 15	10	12.74	15	0.1186
15 - 20	15	17.68	20	0.1648
20 - 25	20	22.63	25	0.2098
25 - 30	25	27.61	30	0.2531
0 - 10	0	7.05	10	0.0954
10 - 20	10	15.79	20	0.2835
20 - 30	20	25.46	30	0.4629
30 - 40	30	35.31	40	0.6282
40 - 50	40	45.22	50	0.7744
50 - 60	50	55.15	60	0.8972
60 - 70	60	65.10	70	0.9926
70 - 80	70	75.06	80	1.0579
80 - 90	80	85.02	90	1.0911

Formulas Used as Indicated in Table I

Mean Candlepower in Zone:

$$I_{mean} = \tfrac{1}{6}\,(I_a + 4I_b + I_c).$$

Lumens in Zone:

$$\phi = k_z\,(I_{mean}).$$

Mean candlepower in a zone is referred to here as that value of candlepower which, if it were uniform throughout the zone, would result in the same number of lumens in the zone as do actually exist.

Basis of Method

This method is designed to eliminate the second of the two sources of error mentioned previously—the fact that the candlepowers at the smaller angles are responsible for proportionately less lumens than are the candlepowers at the angles nearer to 90°. This correction can be made graphically by plotting the ordinary candlepower-distribution curve (Fig. 2A) on "warped" coordinates, with candlepower plotted *vs* the cosine of the angle θ from the axis. Such a scale (Fig. 2B) has the effect of distorting the horizontal distances, so that the curve becomes directly proportional to the lumens within any range. Then it can be seen that the effective midpoint of any range does not lie at the angle half-way between the zone limits, but rather at the angle whose cosine is midway between the cosines of the boundary angles. This then is the basis for the location of the ordinate at the angle "*b*" within each zone.

Unless a continuous integration or measurement of area is to be performed, the first of the two sources of error—the fact that the central ordinate is not necessarily the average—cannot be eliminated completely. However, it can be reduced to a degree which was found in this study to be negligible. This is done by the use of Simpson's rule, which assumes a smooth curve, a portion of a parabola, between any three successive points, rather than a straight line from point to point, as assumed in the more common trapezoidal method. This accounts for the multiplying factors applied to the various terms of the mean-candlepower formula.

TABLE III.—Errors in Computed Lumens for 0°-10° Zone From Preliminary Curves.

Method	Light Source			
	150-w R-40 Spot	300-w R-40 Flood	150-w PAR-38 Spot	150-w PAR-38 Flood
Conventional, 1 interval	20%	2%	20%	1%
Conventional, 2 intervals ..	4%	*	5%	*
Formula, 1 interval	*	*	*	*

*Error is less than ½ of 1%.

Applications

This new method can be used to improve accuracy wherever the conventional zonal-constants method has been used. The improvement will be greatest, of course, with candlepower-distribution curves which are changing sharply or have pronounced curvature, especially in regions that are near the photometric axis (0° and 180°).

As illustrated in the following tabulation, the conventional method shows the greatest errors when applied to a narrow-beam distribution.

The conventional zonal-constants method has been applied to an overlay grid made to be placed over a candlepower-distribution curve drawn on rectangular coordinates. Scales reading in lumens are laid out on the grid. The scales are graduated on the basis of zonal constants, so that lumens in each zone may be read directly. By relocating the scales on the zone angles "*b*," rather than on the ordinary mid-zone angles, an improvement in accuracy results with no added computation.

For results of the recent elections of National and Section officers of the Illuminating Engineering Society, see page 17A.

Illumination of a Laboratory Table

For Inspection of Blood Samples from Bovine Animals

By LUDVIG C. LARSON

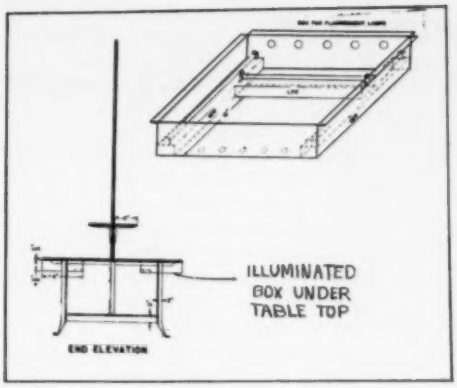
A "before" picture. The enclosing glass bowls (not illuminated) could not be used because images appeared on the glass plates used for viewing the blood samples. The doctor at the left is inspecting blood samples after the addition of brucella antigen.

PROBLEM: The inspection of blood samples taken from bovine animals to determine whether the animals are infected with brucellosis involves two steps requiring critical seeing conditions. These steps are: (1) Pipette deposition of blood samples in the screening test upon glass plates, samples applied at the rate of 500 to 800 samples per hour, and (2) inspection of samples after addition of brucella antigen. This antigen is composed of a suspension of killed brucella abortus organisms to which gentian violet and brilliant green have been added to stain the antigen a light blue color.

The first step, conducted under ordinary laboratory illumination facilities, causes excessive eye and body fatigue because: (a) room luminaires and other light sources (such as windows) appear as reflected images upon the glass plates and interfere very seriously with seeing the ruled-off squares and blood samples, especially when the samples must be applied at the rate of 4 or 5 samples per second; (b) laboratory table tops and surrounding surfaces are usually either black or some other unfavorable color, in sharp brightness contrast with the hospital-white ceilings and walls.

Author: Director, Electrical Standards Laboratory, University of Wisconsin, Madison, Wis.

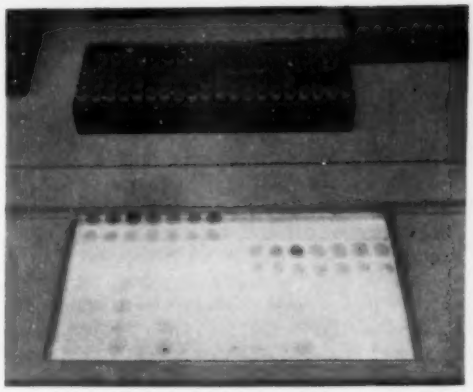
Another "before" view. Note how clearly images of the non-illuminated luminaires can be seen on glass plates. Other very obvious seeing handicaps are the dark furniture finish and the lack of contrast at the seeing task.



SOLUTION: A special table was constructed which had a box or drawer containing three 15-watt T8 green fluorescent lamps. The drawer is 1½ feet in length, 4¾ inches deep and 12 inches across. The table has a ¾" 5-ply fir partition down the center making a separate production line on each side.

Semi-indirect luminaires suspended from ceiling are placed so that images do not appear on blood test plates. The vertical baffle separating the two "production lines" serves to reflect some of the ceiling light upon the work.

This specific solution to a seeing problem in a laboratory was suggested by Figure 1, page 66, of the February 1951 issue of ILLUMINATING ENGINEERING.



"The task." The blood samples have been given contrast against the illuminated box below. The average brightness is about 100 footlamberts. Some technicians prefer lower values, and this is easily provided by turning off one of three 15-watt T8 green fluorescent lamps in the box. Brightness of the area surrounding the illuminated drawer is about 40 footlamberts.

Two "after" views, below. In the photo at right, the doctor on the far left is completing the inspection of blood samples over a 15-watt T8 white fluorescent lamp, placed under the table edge. This lamp is looked at directly during relatively short intervals of time. The left end of the table has a lower level of incident illumination than has the right end. Window shades shown in both these photos are to be painted a light green color to match the table.

Lighting the Boeing Stratocruiser

By R. J. HELBERG

LIGHTING the Stratocruiser presented many interesting problems to Boeing engineers: a lower deck lounge calls for a much different type of lighting than a control cabin; the chair passenger reading until dawn cannot use a light that was designed for reading in a berth; the lights on the stairway could not be allowed to glare into the eyes of little junior or a six-footer coming up from the lower deck; and to top it all off, the lights in all passenger areas had to be modernistic in design and blended into the interior finishing of each customer's airplane.

To insure adequate lighting for the Stratocruiser passengers and crew, over 400 separate lamps had to be designed into the lighting system. Thirty of these are fluorescent lights (some versions have 57) for general illumination in passenger cabin, the lounge, washroom and the galley. The other lights are incandescent and are installed throughout the airplane, varying in rating from the 600-watt landing lights to the tiny instrument lights of less than one-half watt. If all the lights on one of the Stratocruisers were on at one time they would require approximately 6,970 watts.

Exterior Lights

The exterior lights on the Stratocruiser are very nearly standard for commercial airplanes. There are two 600-watt landing lights, the flashing navigation lights, the two 50-watt wing illumination lights, and the taxi light in the nose of an airplane.

The purpose of the taxi light is to provide illumination for maneuvering the airplane around on the ground without the use of the main landing lights, which have a life expectancy of only 25 hours. By using the taxi light instead of the landing light for all ground maneuvers it is possible for the operators to stretch out the service life of the landing lamps to a reasonable number of flight hours. Since none of the lamps available in the required voltage provided the amount and distribution of light and a lamp life appropriate to taxiing service, the lamp manufacturer was requested to develop such a unit. The result was a 28-volt PAR-46 150-watt lamp designed for 300 hours. The new lamp has been installed in some of the Stratocruisers.

Cockpit and Crew Compartment

The problems of proper flight deck lighting have increased with the speed and complexity of modern airplanes. Lights originating within the interior of the airplane reflected from the windows into pilots' eyes can be mistaken for exterior lights or they may prevent proper night adaptation of the pilots' eyes so that the presence of exterior lights in the vicinity of the airplane would not be observed.

Before the Second World War ultraviolet light appeared to be the answer to the problem of instrument lighting. Such light was used on specially

Author: Assistant Project Engineer, Boeing Airplane Co., Seattle, Wash.

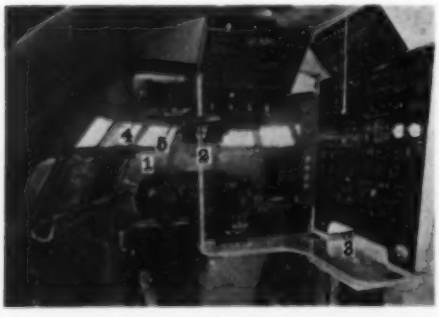


Figure 1. Stratocruiser pilot's compartment (Pan American World Airways) 1. Padded light shield around instrument panel; 2. engineer's panel lights; 3. engineer's table light; 4. forward cabin dome lights; 5. map reading light.

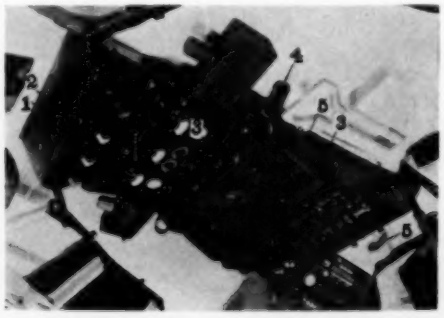


Figure 2. Pilot's overhead electrical panel (front view) 1. Red compass light; 2. white compass light; 3. panel light, red or white; 4. map reading light; 5. light shield.

prepared instrument faces. This left the pilots' compartment in otherwise total blackness, however. Such instrument lighting was thought to be ideal because there were no visible interior light sources and no reflections so that the pilot's attention could be immediaely attracted to any exterior light in the vicinity. However, other troubles soon developed. It was discovered that the image retention of the eye would cause images of instruments to be transferred to new locations in the airplane when the pilot shifted his vision after studying the instruments for some period of time. This trouble appeared to be caused by the sharp contrast between a black or reflectionless panel and the activated figures and pointers of the instruments. In other instances pilots reported "foggy vision" after flying with ultraviolet instrument lighting for some time.

Capt. Carl Christenson, now Flight Safety Engineer for United Air Lines, is generally credited with introducing red light into airplane cockpits. Astronomers and others have long worked with red light or red filters to maintain night adaptation. With this knowledge and his own experience in photographic dark rooms, Capt. Christenson was convinced that red lighting would solve the pilots' night flying problems. Experiments with red lighting in the cockpit of a DC-3 airplane were generally successful and it was agreed that pilots working in a red-lighted cockpit could see out into the night a great deal better than from a white-lighted area. For the Stratocruiser a combination of red and white cockpit lighting has been developed that can be mixed in any proportion suitable to the pilots for prevailing light conditions at the time. As darkness closes in on the airplane in flight, the pilots dim the white light and increase the red. When complete darkness prevails the white light is turned out and the red light adjusted to suitable vision requirements. Members of the crew other than the two pilots and the Flight Engineer may use either white or red light unless the pilot wishes to go aft on the flight deck and still retain his night adaptation. In this case he selects red light for the aft cockpit by the use of switch at his station. (See Figs. 1, 2 and 3.)

Figure 3. Stratocruiser pilot's compartment (Northwest Airlines mockup) 1. Pedestal light; 2. dome light; overhead panel light; 4. light intensity rheostat.

Another factor adding to the complexity of the cockpit lighting problem was the possibility of flying at night in the vicinity of an electric storm. In this case night adaptation is destroyed by lightning flashes so it is desirable to have plenty of white light in the cockpit and thus have crew members' eyes adapted for the bright flashes.

Map Reading Lights

In addition to the standard cockpit lighting in the Stratocruiser some of the airlines required a map-reading light for both pilot and copilot. This light had to have many of the features of a passenger reading light so it was only natural that a standard Stratocruiser reading light bulb be made up into an assembly that could use either a red lens or no lens. The light was made adjustable to suit the needs of the pilots and mounted over the pilots' heads, shining generally downward. These map-reading lights, like other cockpit lights, are wired in series with rheostats for dimming and may be used as spot illumination for other locations in the cockpit if desired. The map-reading light construction is used for other spot lighting around the cockpit. (See Fig. 2). It may be of interest to note that red lighting has the tendency to erase red from maps, etc. Since most maps have some or many red lines or areas pilots must read such maps with caution under red light.

In addition to cockpit illumination, there are approximately 85 indicator lights on various panels on the flight deck. These lights indicate when there is low hydraulic pressure, low fuel or oil pressure, heater overheat, inverter malfunction, and many similar disorders. The philosophy adopted on indicator lights was "No light on indicates operation is satisfactory." The exception to this was with the landing gear indicators where three green lights on indicates it is safe to land. This negative indicator light configuration was adopted because it would be confusing to crew members and impossible from a night vision standpoint to have indicator lights on during normal operation.

The cockpit of the big Stratocruiser is built for pilot visibility. Two extra rows of windows provide excell nt visibility at all times and especially for

Figure 4. Main cabin, forward half.

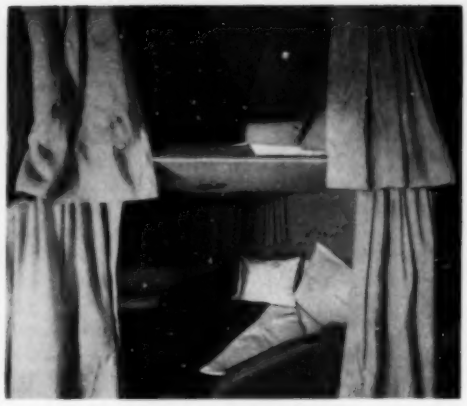


Figure 5. Mockup berths.

landing and takeoff. (See upper and lower rows of cab windows, Fig. 1.) These many windows permit extra visibility by day but they were a nightmare to the illuminating engineers assigned the problem of lighting the flight deck. There were reflections in every window from every light. Gradually, however, after many hours at work in a covered mockup of the crew compartment, fighting reflections one by one, the engineers were successful in getting the light where it was wanted; *i.e.*, on the panels and off the floor and windows. During this period a desperate struggle was waged to get non-spectral black paint. All of the tricks of the trade were tried. Corn starch was mixed with the paint to make it dull, and all possible light colored items, knobs, screw heads, etc. were either shielded from the light or were painted black or dark colors. At last the reflection problem was solved. The worst reflections that will be present in the pilots' windows of the Stratocruiser will be those from the pilot's or copilot's clothing or hands as they go about their jobs of flying the airplane. (See light shield on main instrument panel, Fig. 2.)

Passenger Cabin Lighting

Proper illumination on the flight deck was only one of the big problems that confronted the Stratocruiser illumination engineers. They teamed up with the stylists to design lighting installations in the main passenger cabin to combine beauty with utility.

The first problem was general illumination. Should it be a fluorescent system or an incandescent system? Studies showed conclusively that when an inverter and transformer were charged to the fluorescent system the cost of equipment was four times the cost of an equivalent incandescent system and weighed twice as much as the incandescent system. Until the heavy ballasts normally used with fluorescent lights were eliminated the weight ratio was four to one against the fluorescent. However, the estimated maintenance cost (replacement parts only) in 2500 hours operating time was estimated to be sixteen times as great for incandescents as for fluorescents, and the power consumed would be 915 watts less for fluorescents. Based on these figures alone, it seemed that fluorescent lights should not be used in an airplane. However, when maintenance labor costs are included, the above figures look more favorable for fluorescent lights. Also beauty must be considered. Fluorescent lighting had appeal! The stylists liked its possibilities and the passengers would like it, so it was selected as the general type of cabin lighting.

Boeing engineers guessed that considerable weight could be removed from the ballasts by using condensers in lieu of the much heavier choke coils. The fact that the light power source was 400 cycles instead of the normal 60 cycles made the weight saving possibilities even more promising. Accordingly, a study was initiated to determine the following:

1. What size capacitors must be used to operate the lamps at rated current and wattage?
2. How does the use of capacitors as ballasts affect the power supply, the lamp life, the brightness and the ability to start the lamps?
3. How much weight could be saved?

Calculations were made from data available and tests were run on various components to obtain data not otherwise available. In this way suitable

values for condensers were determined. A test setup consisting of all the circuit arrangements used in the airplane fluorescent system was built. The conclusions reached were as follows:

1. Capacitor values for the lamps depend on the supply voltage. For the 208-volt, 400-cycle supply the capacity for both the 32-watt circline and the 30-watt straight tube was 0.60 microfarad.
2. The use of condensers will reduce the life of the lamps due to cold cathode starts and high peak currents. Starters could be designed to heat properly the cathodes but such starters are not now available.
3. Lumen output of capacitor ballasted lamps is equal in intensity to that of conventional inductively ballasted lamps.
4. Lamp starting will be faster but harder on lamp life with the capacitor setup.
5. The airplane inverter cannot be operated at the low leading power factor up to its full VA rating. For this reason the 15-watt lamps are operated on core and coil ballasts which have a lagging power factor effect. Thus, when only the dressing room lights are on the inverter power factor is low and lagging. When the main cabin lights are turned on, however, the leading power factor tendencies correct the overall power factor and the system operates at near unity power factor when the higher load is on the inverters.
6. The value of capacitor ballasts for fluorescent lights lies in the weight saving it makes possible. In installations where weight is unimportant this method of operation would be questionable.

Several trials eliminated straight fluorescent tubes for the main cabin lighting, so that luminaire design here centered around the circline type. Models of several designs were installed in an airplane mock-up for study by stylists and others.

The type chosen has a translucent plastic diffuser, circline lamp, and provides approximately six footcandles illumination of good uniformity at arm rest level. Nine of these units are in the main cabin. Three of the long 32-watt lamps are in the galley, twelve 15-watt straight lamps are in dressing rooms, with seven in the bar and lounge. All of the fluorescent lamps used are the soft white type.

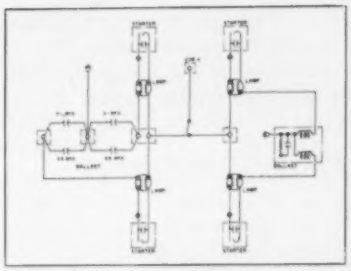


Figure 6. Wiring diagram. Typical for both capitance and inductance ballast. Note that inductance ballast condenser is by-passed.

Secondary Lighting

Where passenger comfort and convenience dictate the lighting requirements it is not enough to consider only general lighting. Provisions must be made for low level lighting when passengers are being loaded or unloaded late at night, without unduly distracting sleeping passengers. For this service each of the circline luminaires carries a single 8½-watt incandescent light in its center.

When the airplane is cruising through the late night or early morning darkness a third and still lower level of lighting is required. For this pur-

Figure 7. Lounge, looking aft.

Lamp Department, General Electric Co.

Figure 8. Reading light for passenger cabin.

pose sodium lights are mounted low on the aisle side of the seats and in the dressing room walls, to provide sufficient illumination to move about without disturbing restless sleepers.

Lounge Lighting

Lounge passengers should not be conscious of any source of light but there must be sufficient light of low level for visiting and general passenger comfort. To accomplish this objective six 30-watt fluorescent lamps are installed below the backs of the passenger seats. The light from this source is upward and is reflected off the walls, ceiling and the mirrors at the forward end of the lounge. The effect is quite pleasing.

Reading Lights

Like the general cabin lighting the reading lights in the luxury liner were designed to passenger specifications. An area equal to an open magazine must be evenly lighted to a relatively high level for long periods of reading. The light must be glare free for both the reader and the person in the next seat. The source must be inconspicuous; in fact, it must be completely hidden behind the airplane lining with only a small hole to shine through. The light control switch must be mounted in the arm of the passenger's chair.

These problems, plus the problems of mounting and providing adequate adjustment for the reading light had to be solved by the illuminating engineers.

The question of the proper illumination level was difficult to resolve. Many authorities had given 25 to 40 footcandles as proper for reading. This level, however, was based on the reader being in a lighted room, not in a dark room with only the one spot of illumination. The contrast of lighted magazine to the light in the surrounding area we considered very important. Approximately 14 footcandles was finally settled on as feasible illumination of reading, in the circumstances.

Once the desired lighting level was established, all sorts of designs were tried in an effort to produce that level with sources available. Lenses, mirrors and combinations thereof were tried. The solution evolved by the lamp manufacturers was the present 21-candlepower lamp with built-in reflector. It consumes only 20 watts but due to the built-in reflector provides enough light to permit the losses incident to beam control and will supply 12 to 20 footcandles of illumination. This source has been adopted for all Stratocruiser reading lights. It could be mounted behind lining, in the bottom of berths, and in racks; it could be mounted to give direct light, or by the use of mirrors, it could be mounted in a thin structure such as a berth and the light deflected to the reading material, and still give sufficient light of good uniformity to meet the requirements of good illumination.

Work lights, such as those in the cargo areas, equipment compartments, wheel wells, etc., are designed for efficiency, maintenance and space availability. That is, they must light the desired areas, be easy to maintain, and be mounted in such a way that they will not be bumped or otherwise damaged by workmen inspecting or loading the airplane.

In general, the Stratocruiser lighting is designed to be where it is wanted when it is wanted and at an illumination level adequate for the service intended. When general darkness is desired, individual lights in both passenger and crew compartments have cutoffs that prevent stray light going over into areas where it is not wanted, or reflecting from windows into the eyes of passengers and crew.

References

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2. Aircraft Cockpit and Instrument Lighting. John M. Roper, Lighting Engineer, Bureau of Aeronautics.

Business Directory of I.E.S. Membership

An accurate up-to-date business directory of the entire membership of the Illuminating Engineering Society has been compiled under the direction of the Publications Committee, to be available only to members of the Society. Copies of the directory, 6 x 9 inches in size, may be obtained from I.E.S. headquarters at $2.00 for single copies, or $1.75 each for quantities of ten or more.

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The Cause of the Humidity Effect In Fluorescent Lamps

By ROBERT H. McFARLAND

MANY writers[1,2,3] have been concerned with the measurement of the increased starting potentials of gaseous discharge devices under increasing humidity conditions. It is the purpose of this paper to extend the above works to include the "why" of humidity effect. In accomplishing this it is necessary, as is customary in most gaseous discharge papers, to resort to a description of a series of related experiments to obtain enough information so that a hypothesis concerning the effect may be proposed.

Previous work of the author[3] had shown that increased starting potentials were to be expected when the surface resistance of a 40T12 fluorescent lamp was in the range of 10 to 10,000 megohms. At higher or lower surface resistances starting potentials were found to be normal. Also, one was able to reproduce these data with lamps banded with metallic foil, as shown in Fig. 1. In this experiment, surface resistances similar to those of a humidity-affected lamp could be simulated by varying the magnitude of r and R. Use of this lamp made survey measurements much simpler than would have been possible in a humidity chamber. The problem still remained as to why normal starting was to be observed at both high and low surface resistances.

Investigatory Experiments and Results

A. The Effect of Controlled Potential Gradients Along the Lamp.

By changing the relative values of R and r of Fig. 1, the potential gradients along the banded lamp can be changed. The results of a typical experiment of this type are shown in the first two columns of Table I where the value of r was held at 100,000 ohms and R was varied from zero to infinity. The starting potential, V_s, increased with decreasing values of R. Similar results occur with other values of r as long as the total resistance across the banded lamp does not exceed approximately 10,000 megohms.

For the lamp starting conditions of Table I as given above, it was possible to calculate and tabulate in columns 3 and 4 the potentials applied to different parts of the lamp. The potential V_c applied at the time of starting between the ungrounded electrode and the third band from the end of the lamp, 3 cm. distant, may for practical purposes be found by the relationship:

$$V_c = \frac{2r + R}{30r + 2R} \cdot V_s$$

(Note: The capacitances which are of the order of 10^{-12} farads may be disregarded here in comparison to the resistances of the order of 10^5 ohms.)

The potential V_L existing across the lamp surface under these conditions is:

$$V_L = \frac{30r}{30r + 2R} \cdot V_s$$

While V_c is found to be nearly constant for all of these starting conditions, V_s and V_L are very different. This shows that a potential greater than 99 volts must be applied across only a few centimeters of lamp gas adjacent to the electrodes to start the discharge. Investigation with an oscillograph of

TABLE I.—Starting Conditions When R is Varied.

$r = 100{,}000$ ohms

R (megohms)	Starting Volts V_s	Band to Electrode Pot. V_c	Volts Across Lamp Surface V_L
∞	300	—	—
5.0	300	119	71
2.0	330	102	144
1.0	425	102	250
.5	580	99	438
.25	900	113	775
.15	1120	116	1020
.10	1200	109	1127
.05	1400	109	1356
0	1800	116	1800

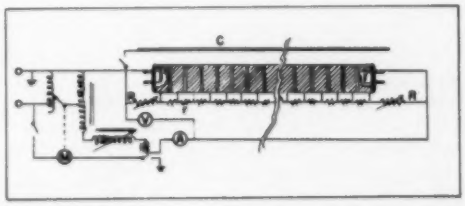

Figure 1. Special circuit used for starting lamps and producing controlled lamp gradients.

Author: Department of Physics, Kansas State College, Manhattan, Kansas.

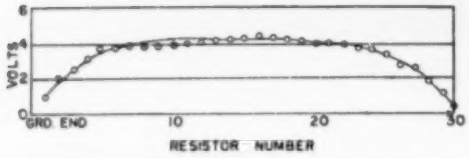

Figure 2. The potentials existing across the resistors, r, of Fig. 1 prior to lamp starting. This indicates the means by which approximately uniform potential gradients are applied across the lamp surface even though R = ∞

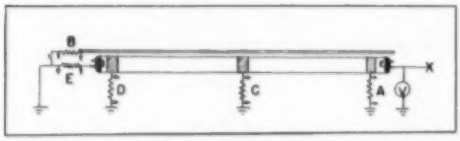

Figure 3. A circuit used for investigating the onset of current in different parts of the lamp. An oscillograph was connected across the different lettered resistors and used as a current indicator.

current initiation when a potential was applied directly between this band and cathode showed that a potential difference of from 100 to 120 volts was required to initiate the first discharge currents. These experiments are described more fully in Section C.

B. Distribution of Potential Gradients Along a Lamp.

In order to investigate the potential distribution along the banded lamp when R was infinite, measurements of voltages between consecutive bands of the lamp were made with a high impedance, R.M.S.-reading, peak-measuring, vacuum tube voltmeter. For these measurements the bands were linked by thirty 100,000-ohm resistors. The lamp potential was increased to approximately 300 volts, which was just below that required for starting. The potential existing across each of the 30 resistors is shown in Fig. 2 to vary from 0.2 volts near the ungrounded electrode to more than 4 volts at the center of the lamp. Fig. 2 refers only to the voltage across successive resistors and not to the voltages between the cathodes and the end bands, which must approach 100-120 volts at starting.

TABLE II.—The Potential Difference Required to Initiate Current Between the Cathode and Different External Auxiliary Anodes as Seen in Fig. 3.

Resistor	V at Current Onset
A	120 V
B	135 V
C	170 V
D	180 V
E	185 V

C. Currents During Starting.

A circuit for investigating discharge currents set up by potentials applied to different parts of the lamp and the potentials required for initiating those currents was used as shown in Fig. 3.

An oscillograph connected across the lettered resistors was used to indicate the onset of current at different parts of the circuit. The potentials required to initiate these currents are shown in Table II.

The shape of the current wave, plotting current against time, through resistor A was observed by cathode ray oscillograph. At its onset at 120 volts it consisted of a single sharp pip occurring but once during each half cycle. As the lamp voltage was increased above 120 volts, the magnitude of the pip remained practically unchanged. At approximately 125 volts, however, a second pip similar in shape to the first appeared in each half cycle a few thousandths of a second after the first. Further increase of potential caused additional pips to occur which followed the first two in equal time intervals. Three of these pips may be seen in their relationship to their applied sinusoidal potential in Fig. 4. As the applied potential was decreased, the pips disappeared at the potentials at which they had first appeared. The pips were nearly the same height and width, with the ones occurring during the part of the cycle when the filament was the anode likely to be slightly sharper than when it was the cathode. The first pip to appear in each half cycle was slightly greater in current magnitude than subsequent ones. In a darkened room small flashes of light could be observed emanating from the electrode when the potentials were great enough to cause these current pips to flow. The magnitude of these currents as measured with the oscillograph had peak values of a few microamperes.

The shapes of the current waves through the other resistors B, C, D, and E were broader and less regularly spaced than was that through resistor A. The current through B was ordinarily quite broadened, particularly during the half cycle when the reflector became the anode. Except for these distortions, the currents through these other resistors behaved and appeared much as did the current through resistor A.

D. Discharge Currents Set Up by Auxiliary Electrodes.

1. 40T12 lamps were constructed with a nickel electrode placed inside the lamp near each of the ordinary lamp electrodes. Several different types of electrodes were used. A band was placed at one end of the lamp in the same position as the one in Fig. 3 connected through resistor A to ground. A

potential difference was then applied successively through a resistor (1) between the lamp electrode and the band, (2) between the nickel electrode and the band, and (3) between the nickel electrode and the lamp electrode. The current for each pair of electrodes was observed with an oscillograph. The currents for electrode pairs (1) and (2) were identical with currents through resistor *A* of the previous experiment. The current through electrode pair (3) was that of a partially rectified glow or arc. If a small condenser was connected in series with (3), its current changed to become identical to that through resistor *A*. This shows that currents of this type are independent of electrode material.

2. A lamp with extra internal electrodes such as described above was used in an experiment to obtain ionization of the gas surrounding the lamp electrodes at a lower potential than could be obtained without the extra electrodes. In this experiment each extra electrode was connected through a variable resistor to the lamp electrode at the opposite end of the lamp. Thus the entire lamp potential was applied across each of the gaps between the lamp electrode and the nearby nickel electrode until current began to flow in this gap. This initial current flow started at approximately 120 volts, and the discharge filled the entire lamp at approximately 165 volts under low humidity conditions. This lamp was observed to have more than 150 per cent increase in starting potential with increased humidity regardless of the amount of ionization produced at the ends of the lamp by the extra electrodes.

3. A similar experiment was made in which the extra electrodes were in the form of external bands. These were like the bands at the end of the lamp of Fig. 3 and were connected to the electrodes at the opposite ends of the lamp as in the previous experiment. This lamp was observed to have a starting potential of approximately 450 volts at high humidity.

4. On the other hand, a specially constructed 40T12 lamp in which a conductor inside the lamp extended from a position close to one electrode to a position close to the other electrode was found to have a starting potential independent of ambient humidity. During the starting of this lamp, a discharge was first observed between the two lamp electrodes and the two nearby ends of the conductor. As the lamp voltage was increased further, the ends of the two separate discharges terminating on the conductor spread over a larger area of the conductor which led the discharges toward the center of the lamp. When these discharges met at the

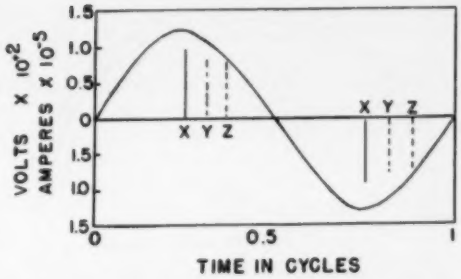

Figure 4. Current pips X, Y, Z are observed with an oscillograph to flow through resistor A of Fig. 3 when a sufficiently great sinusoidal voltage is applied to the lamp. The number of pips which appear is dependent on the magnitude of the applied potential. Only pip X is observed if the lamp potential is less than 125 volts.

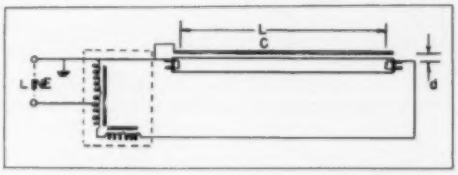

Figure 5. An electric circuit such as is used for operating a single 40T12 lamp.

center of the lamp, a single discharge formed between the electrodes at the extreme ends of the lamp to cause normal operation. The electrode potential drop of the conductor was sufficiently greater than the gradients presents when the lamp was operating normally that negligible current flowed through the conductor after starting.

Results

Under normal lamp starting conditions, a lamp with one electrode grounded is started in a grounded metallic reflector as shown in Fig. 5. Thus the voltage which is applied across the lamp during starting exists also between the reflector and the ungrounded electrode of the lamp through the distance *d*. Since this voltage ordinarily must be between 250 and 300 volts in order to condition the cathodes so that the discharge can change from a glow to an arc, it is larger than necessary to produce ionization in the lamp atmosphere between the reflector and the ungrounded electrode. The ionization of the lamp atmosphere may be thought of as being initiated as a brush discharge by the potential gradient existing between the ungrounded electrode and the nearest point of the reflector when the applied potential is approximately 135 volts.

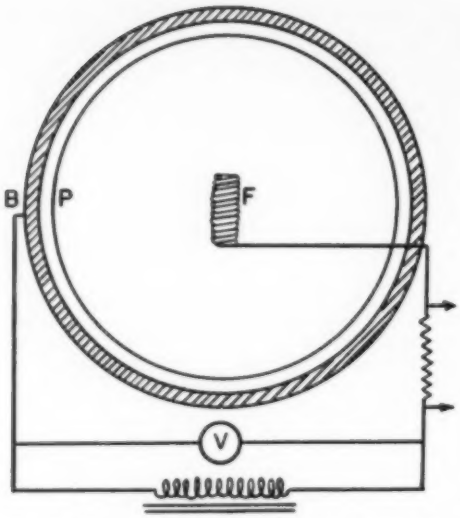

Figure 6. Circuit used for examining and explaining the formation of current pips observed during lamp starting.

As this potential is increased, the current also must increase and does so by spreading down the lamp with the reflector still being used as the second electrode in a fashion similar to that of the lamp with an internal conductor described in Section D4. When the discharge approaches close to the grounded electrode of the lamp at approximately 185 volts, a discharge is formed extending between the two lamp electrodes. (It should be noted here that lamps started without a reflector and not affected by humidity will require potentials greater than 185 but less than 300 volts to form the initial discharge between the two electrodes.)

Under high humidity conditions, starting is much more difficult. As was shown for a particular case in Section C with the banded lamp, potentials ranging from 0.2 volts to more than 4 volts can be detected as existing between bands when the potential applied across the lamp is slightly under the required starting potential. The manner in which these potentials may be produced is as follows: As the potential across the banded lamp is increased, purely capacitive currents start to flow immediately between the electrode and adjacent bands at one end of the lamp — along the surface of the lamp — and then through band-electrode capacities to the electrode at the opposite end of the lamp. Since the resistors at the ends of the lamp carry current from fewer of the band-electrode capacitances than do those at the center of the lamp, the currents through, and hence the potentials across these resistors are less than those at the center of the lamp. Thus not only are the potential gradients produced by these capacitive currents across the lamp kept surprisingly small, but the greater potential gradients are produced at the center of the lamp. Under these conditions it is only with unusually large applied starting potentials that it is possible to produce potentials greater than 100-120 volts between the ungrounded electrode and the adjacent lamp surface which is necessary for starting.

As the banded lamp so closely approximates the action of a humidity-affected lamp in starting, we can assume that the layer of water absorbed by the lamp surface performs as do the bands to control the potential gradients along the lamp and to reduce the gradients at the end of the lamp.

For relatively low or extremely high surface resistance, however, additional explanation is necessary. In the first of these cases, since the capacitive currents involved are necessarily limited by the small capacitances involved to values of the order of 10^{-8} amperes, the potentials built up across the lamp surface are limited to but a few volts. In this instance, almost the full applied lamp potential is divided between the two electrode-lamp surface gaps at the ends of the lamp. Since not more than 120 volts is required to initiate a discharge at these points, the lamp's atmosphere is made conducting at a potential well under that of the 250 to 300 volts necessary for conditioning the electrodes.

In the instance of the surface resistance approaching values of 500 megohms or greater, a second phenomenon occurs in which the impedance along the lamp surface becomes greater than the capacitive reactance between the surface of the lamp and nearby capacitive objects such as the grounded reflector. In this case the potential of the reflector imposes an increasing influence on the potential at the surface of the lamp until at the time when the surface resistance approaches infinity. The full lamp potential is applied uniformly between the reflector and the ungrounded electrode to produce favorable starting conditions.

The action of the surface film of a humidity-affected lamp has much in common with the screen grid of a tetrode. Through its voltage-distributing action it impresses a relatively small potential difference between the surface of the lamp and the electrode at the ungrounded end of the lamp. Thus the surface of the lamp effectively screens this electrode from the reflector which could produce much greater gradients and which corresponds to the plate in the tetrode. Under hard starting conditions, several hundred volts may be applied between the reflector and the surface of the lamp; but if

less than the required 100 to 120 volts exists between the surface and the ungrounded cathode, the lamp will not start.

The explanation of the appearance of the currents seen in Fig. 4 and described in Section B lies in the electric circuit. An end view of the lamp and its circuit is shown in Fig. 6. This circuit essentially consists of a condenser and a glow discharge tube in series with a source of potential difference. The condenser has as one plate the band *B* around the lamp and as the other the inner wall of the lamp envelope *P*. The glow discharge tube uses this same inner wall *P* as one electrode and the filament *F* as the other.

As the lamp potential is increased, the ignition potential of the glow tube is reached. The gas breaks down and the condenser is charged. This lowers the potential across the glow tube below the ignition potential and current flow stops. The amount of current which flows depends on the capacitance of the condenser. This accounts for the shape and size of the first current pip *X*. The second current pip *Y* is dependent on the voltage across the glow tube again reaching the ignition potential. This is impossible if the peak of the applied voltage is no larger than ignition potential of the tube. If, however, the applied voltage is sufficiently high, the condenser may discharge by leakage until the ignition potential of the glow tube again is reached. Repetition of this process with increasing voltage accounts for the number of current pips which are observed during each half cycle.

The discussion of starting thus far has dealt largely with the importance of producing ionization at or near the electrodes. This has been with the understanding that there would be sufficient potential gradient along the lamp to extend the ionization throughout the lamp once it is initiated. If this were not necessary, an obvious solution to the problem would be to ground a band encircling the ungrounded electrode. This procedure does assist in initiating the discharge, but such a lamp still has almost 100 per cent increase in starting potential at high humidities over the starting potential necessary at low humidities. The reason for the failure of this circuit to reduce the starting potential is that although the band originally causes the whole lamp surface to be at ground potential, it does not remain so. Brush discharges are initiated between the ungrounded electrode and the grounded band. Increasing the applied potential causes this current to increase which it does by using a larger area of the inner wall surface near the band as an electrode. Charges arriving at the inner wall surface between the grounded band and the grounded electrode cause a current to flow along the outer wall surface to either the grounded electrode or the grounded band. The resultant *IR* drop causes the central portion of the lamp to have a smaller potential difference with respect to the ungrounded cathode than does the grounded band. This imposes a potential barrier to keep the discharge from spreading down the lamp.

Prevention of the Humidity Effect

Curve *A* of Fig. 6 of previous paper[3] indicates two of the methods by which the humidity effect may be overcome. It is to be seen that the lamps start relatively easily if the surface resistance is below 15 megohms or above 1500 megohms. Therefore, the lamp surface may be made conducting or be made to have a highly resistive coating under humid conditions. Either of these methods is equally effective in eliminating the humidity effect.

A third method which may gain future importance is that of using an internal conductor down the length of the tube.

Conclusions

Local potential gradients across an a-c gaseous discharge tube may be kept small by the action of leakage currents along the tube's surface. This results in elevated starting potentials and is known as the humidity effect when the leakage paths are caused by high ambient humidity.

Methods of elimination of this undesirable effect include eliminating the leakage path by the use of silicones and increasing the potential gradients at the cathode by decreasing the potential drop along the lamp due to leakage currents. This latter may be accomplished by increasing the conductivity of the entire lamp surface as the currents involved are small.

Acknowledgments

Acknowledgment is made to members of the Sylvania General Engineering Laboratories, Lamp Division, and to Dr. E. F. Lowry for their helpful suggestions. Acknowledgments are also due Dr. J. G. Winans of the University of Wisconsin for suggestions and assistance in writing this paper.

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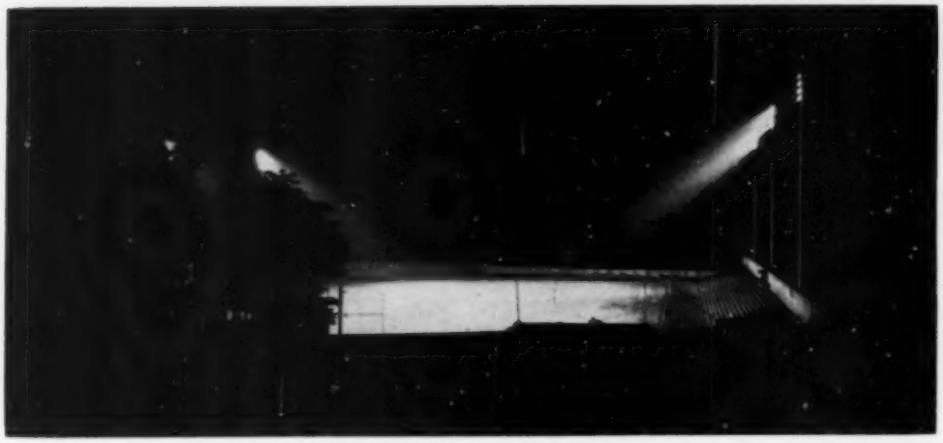
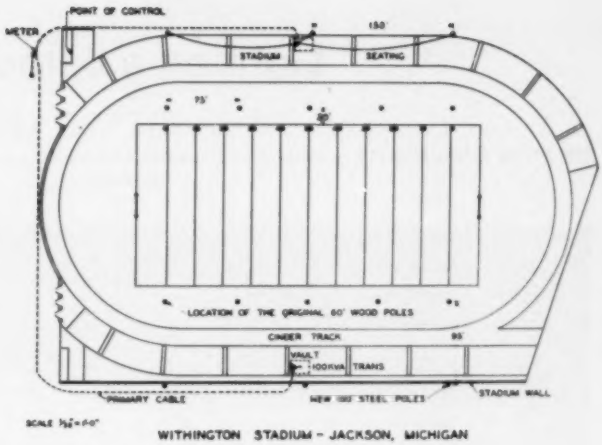


Twenty Years of Nighttime Sports

This installation was second-place winner in the contest held by the Michigan Section, I.E.S., on "My Most Interesting Lighting Installation." Information and photographs were supplied by Leslie D. Lyon, Lighting Engineer, Consumers Power Co., Jackson, Mich.

OVER two decades ago, in September 1930, the first nighttime football game was played in the Withington Stadium, Jackson, Michigan. It was considered a terrific innovation, receiving wide acclaim and recognition. As with professional sports, it was an immediate practical success as well as a novelty. Gate receipts were something like 130 per cent over the preceding year; 50 per cent of the installation cost was retired the first year.

Poles for the new installation were erected from within the stadium, by hoisting them over a 20-foot back wall of the stadium. Six such poles are used, three on each side.



WITHINGTON STADIUM - JACKSON, MICHIGAN

Plan view of the stadium, showing the original location of poles (1930) and the new layout (1950) where poles are installed behind the spectators to avoid glare.

The installation consisted of forty 1000-watt copper-bronze floodlights, totally enclosed and equipped with mirrored glass reflectors and heavily stippled lens. Floodlights were grouped in fours on 60-foot wooden poles, five on a side, located twenty feet from the side lines on the 0-, 25-, and 50-yard lines. The field was served from a secondary distribution system, each pole being fed underground. The average illumination was six footcandles. Cost of the installation was just under $4000.

By 1940, however, Jackson was below the average of many newer fields. The original installation of 1930 was revamped and forty additional open-type Alzak floodlights with 1500-watt, 110-volt lamps were added on another crossarm. This installation increased the footcandle level from the original 6 to approximately 15 for an expenditure of $3200.

Another ten years passed, and by 1950 the original 1930 equipment was showing the effects of time and weather. In addition, one of the main objections to the existing installation was the position of the poles — in front of the spectators — which caused glare due to the low mounting height, as well as interference in following the play.

A redesign of the entire lighting system was considered necessary and a study was made of the most recent types of installation. The decision was to locate the supporting equipment and floodlights in back of the stands approximately 95 feet from the side lines, using three locations on each side. Six 110-foot steel poles, equipped with steps with a 14-inch diameter butt and 8-inch top, were set in concrete shelves ten feet in the ground. These poles were erected from within the stadium and then hoisted over a 20-foot back wall with a crane. Each pole was fabricated at the top with angle iron cross braces to take four rows of six floodlights each. Each floodlight was individually fused from a weatherproof distribution panel located adjacent to the fenced "cat-walk" and plugged in.

The field is served from a 5000-volt primary, metered at the street, cable being extended in fiber duct to midway on either side where 100-kva transformers were installed in vaults under the bleachers. These transformers are controlled with solenoid-operated oil switches remotely operated from the ticket office. From the transformer vaults all wiring to each pole is from an underground system and fed to the floodlights up through the steel poles. Only a three-volt drop was obtained from transformer to the most remote floodlight.

One hundred forty-four narrow-beam floodlights were installed, each equipped with 1500-watt, 110-volt lamps, resulting in approximately 236 kw. Lights were focused and adjusted from a "daytime aiming chart." Footcandle intensities average 25 or more. Cost of the complete installation was approximately $22,500.

The outstanding features of this modern installation are:

(1) Elimination of all viewing constructions for the spectators,
(2) Glare reduced to a minimum,
(3) Complete safety — all wiring underground or enclosed. Primary and transformers "dead" when not in use.

The field is used not only for football. Track meets, band festivals, fraternal and convention presentations and parochial school games have taken place in the stadium, making it an outstanding civic improvement.

Lighting a Billboard

LIGHTING OBJECTIVE: To provide evenly distributed illumination on a sign for advertising purposes and plant identification.

Installation at United States Radiator Corporation Pacific Steel Boiler Division Plant, Bristol, Pa. Lighting designed by A. V. Schafer, Philadelphia Electric Co.

General Information: The sign faces a highway and is parallel to the main tracks of the Pennsylvania Railroad. The main section measures 12 x 108 feet and is 4 feet above the ground. (The 6 x 29 foot top section was added after the lighting was installed.) The black letters (7% RF) are 6 feet high with a 20-inch stroke on a white background (75% RF).

Lighting Installation: The sign is illuminated by ten Benjamin Type RD flood lights (#5877) with 750-watt general service lamps mounted on the ground 25 feet in front of the sign. Ribbed glass lenses provide a rectangular beam pattern. The first floodlight is mounted 10 feet from the end of the sign with subsequent units spaced at 20-foot intervals.

The result is an average illumination level of 20 footcandles on the sign surface (maximum—30, minimum—10) with an average background brightness of 15 footlamberts. Visibility distance is about 300 feet with the first indication of the sign at approximately 600 feet.

Lighting data submitted by George T. Anderson, Philadelphia Electric Company, Philadelphia, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

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Recent Developments in Visual Low-Approach And Landing Aids for Aircraft

A digest of a significant paper by Dr. Maurice A. Garbell* on comprehensive tests set up and directed by him at the ANC Landing Aids Experiment Station, at Arcata, California.

FROM July 1, 1948, to October 1, 1949, Dr. Maurice A. Garbell was Consultant-in-Charge and Technical Director of the ANC Landing Aids Experiment Station (LAES) at Arcata, California, where the ANC Subcommittee on Visual Aids to Air Navigation (U. S. Air Force, U. S. Navy, and Civil Aeronautics Administration, with advisory participation by the Civil Aeronautics Board, the Air Transport Association, and the Air Line Pilots Association) sponsored flight tests of visual aids to the landing of aircraft in restricted meteorological visibility.

The principal purpose of the flight testing at Arcata was to determine the relative effectiveness of the visual guidance afforded by various patterns of lights in the approach zone and along the runway submitted by government agencies, manufacturers, and others. Additional objectives included the evaluation of fog dispersal, runway markings, and taxiing guidance.

On October 25, 1949, Dr. Garbell presented a comprehensive, detailed five-hour report on "Recent Developments in Visual Low-Approach and Landing Aids for Aircraft" at the Annual Conference of the I.E.S. Aviation Lighting Committee at Indianapolis, Indiana.

In his paper Dr. Garbell reviewed step by step the methods originated by him and standardized at LAES for testing and evaluating the relative effectiveness of various visual landing aids in providing three-dimensional visual guidance in weather conditions when the natural ground plane is not visible to the pilot of an approaching aircraft. Findings in detail on approach, runway-marker, and taxiway lighting were presented and analyzed by Dr. Garbell, together with his further flight experimentation in the United Kingdom and elsewhere in Europe.

The paper culminated with the presentation of a new approach-light pattern conceived by Dr. Garbell and tested at LAES in 1949. Since then the system has been used in scheduled commercial airline operation, in conjunction with the longitudinal rows of the CAA slope line system; this combined configuration is the only landing-aids system in use today that has justified the lowering of CAA weather minimums to an unprecedented 100-foot ceiling and ¼-mile meteorological visibility.

The digest* that follows is an abstract of the new basic information contained in Dr. Garbell's paper, preceded by a summary describing briefly the function and performance requirements of visual low-approach and landing aids for the reference of the reader who may require an introduction into the nature of airport and airway lighting.

Functions of Visual Aids

Visual aids are a necessary component element of a system of landing aids essential in guiding the pilot to a safe touchdown on the landing runway in conditions of restricted meteorological visibility, in daylight and in darkness.

In the "instrument phase" of a bad-weather approach, the pilot is guided in his approach toward the instrument runway by either an electronic Instrument Low-Approach System (ILAS/ILS) or a Precision Approach Radar (PAR/GCA), or both, until the aircraft reaches a point on its straight final glide path located 3000 to 4000 feet from the runway threshold, at an ideal altitude of 200 to 250 feet. From that point on downward, it is generally agreed, the pilot should be enabled to complete his final approach by "visual contact" and not by reliance on electronic instrument aids solely. Flying by "visual contact" implies that the pilot orients himself on the natural ground

*Dr. Garbell is President of Maurice A. Garbell, Inc., Aeronautical Consultants, and President & Director of Research of the Garbell Research Foundation, both of San Francisco, California.

*A more extensive technical digest, including pertinent bibliography, is published by the Garbell Research Foundation, 1714 Lake St., San Francisco 21, Calif. ($0.60).

The Annual Reports of the Landing Aids Experiment Station for 1948 (4 volumes) and the Final Report for 1949 are available at the Office of Aviation Information, Code W-40, Civil Aeronautics Administration, Washington 25, D. C.

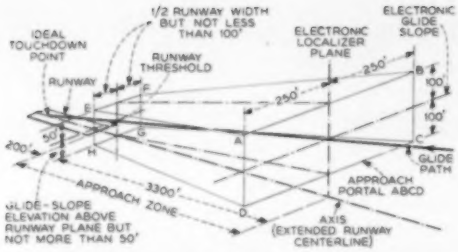

Figure 1. Definition of ANC region of visual guidance (ABCD-EFGH).

surface (the "ground plane") before and beneath him, or otherwise — when the ground surface is invisible — on lighting aids used as a substitute.

The approach lights are intended to guide the pilot from the aforedefined point of "visual contact" to the runway threshold; hence, approach-light systems extend approximately 3000 feet into the approach zone. Longitudinal spacing between individual approach-light fixtures, usually, is 100 or 200 feet.

Runway-marker lights are designed to outline the runway and identify its various longitudinal portions; they are spaced 25 to 200 feet apart, longitudinally, a few feet outside the paved runway surface.

Approach lights and runway-marker lights are aimed substantially toward the approaching aircraft; they should not be confused with floodlights previously employed in unsuccessful attempts to illuminate the runway surface.

"Region of Visual Guidance" and Guidance Requirements

The ANC operational specifications for approach-light systems are based on the assumption that the available electronic aids will enable the pilot to follow the instrument glide path until he crosses an "approach portal" (rectangle ABCD in Fig. 1), and that a satisfactory landing can be expected if adequate visual guidance is afforded the pilot shortly after he crosses the approach portal ABCD. The ANC specifications require that approach lights provide adequate visual guidance at any point of the ANC "Region of Visual Guidance" as defined by the space ABCD-EFGH in Fig. 1.

The LAES flight tests were set up to ascertain the effectiveness of the various approach-light systems in achieving the following objectives:

(1) Visual contact should be had shortly after passing through any point of the approach portal ABCD located at 3500 feet from the runway threshold.

(2) The visual guidance afforded the pilot by the approach lights should enable him to correct any possible deviation from the electronic glide path, both vertical (up-and-down) and transverse (right-and-left), before he reaches the runway threshold.

(3) The approach lights must afford a striking warning of any dangerously low approach and any dangerous directional divergence from the axis of the system, i.e., the extended runway centerline.

(4) When the natural horizon is invisible, adequate horizon guidance must be provided by the approach-light system to control any lateral banking of the aircraft, whether voluntary or otherwise.

(5) Clear indication should be provided by the lighting configuration of the distance remaining between the aircraft and the as yet invisible runway threshold.

Flight Test Procedure

(1) Flight tests were undertaken when ceiling and visibility stabilized at less than 100 feet and one-quarter mile, respectively, and discontinued when these values exceeded 200 feet and one-half mile. Fog conditions during the tests ranged from low stratus to ground fog and included total darkness, twilight, and bright daylight.

(2) Electronic guidance for the "instrument phase" of each test approach was provided by either ILAS or GCA. All approaches were monitored and graphically tracked at the GCA unit.

(3) While nearing the "approach portal," the pilot continued to descend on instruments, while the copilot was on the look-out for approach lights. At first sight of lights the copilot called out "lights" and reported the number of units "first seen" and "carried."

(4) The pilot attempted to "go contact" as soon as he judged the visual guidance adequate, either from the reports of the copilot or from his own occasional glances ahead.

Collection and Recording of Data

The trajectory of each test approach was automatically recorded on graphs showing the vertical and transverse deviations of the aircraft from the ideal glide path; the graphs also included 10-second time marks and 2500-foot distance marks.

Simultaneously all voice communications between the test aircraft and the ground stations were recorded, with synchronous aural 10-second time marks and 2500-foot distance marks superimposed for positive time-and-location identification of every word spoken among the participants in the test.

All of the data collected during each flight test, supplemented with pilots' comments and a detailed weather summary, were recorded in formal Flight Test Reports. Factual data recorded for each test approach included:

Weather:

Ceiling measured in the approach zone and the touchdown zone;

Horizontal visibility observed and/or measured throughout the approach zone and along the entire runway;

Uniformity of fog (as distinguished from patchiness);

Stratification of fog (ranging from ground fog to stratus clouds);

Prevailing brightness above and below the horizon;

Wind velocity, direction and speed.

Approach Lights:

Configuration and intensity setting;

Location of point of first sight (usually copilot's running report timed on voice record and located on GCA trajectory graph); coordinates identified as follows:

X—Distance along axis between aircraft and runway threshold;

Y—Transverse distance (right and left) between aircraft and vertical plane through axis;

DZ—Elevation of aircraft above or below the ideal glide slope;

Number of approach lights first seen, usually by copilot;

Number of approach lights carried, running account throughout the approach zone; lights in right and left rows reported separately; reports usually made by copilot during the approach, supplemented by pilot immediately following the approach;

Location of point at which the pilot went "CONTACT."

Runway-Marker Lights and Runway Surface Markings:

Configuration and intensity setting of lights;

Location of point of first sight (copilot; *X*, *Y*, *DZ*);

Number of runway-marker lights first seen; copilot, right and left;

Number of runway-marker lights carried; copilot, right and left;

Comparative estimate of length of string of runway-marker lights and runway-surface markings carried.

TABLE I.—Location of Point of First Sight of Approach Lights.

DAY

Daylight Object Visibility	⅛ mi.	¼ mi.	¾ mi.	½ mi.
Expected distance of point of first sight from runway threshold	2700 ft. ± 1000 ft.	2900 ft. ± 1000 ft.	3200 ft. ± 1000 ft.	3600 ft. ± 1000 ft.
Single-Row, (C) and (D)	55% of test approaches below expected distances			
Two-Parallel-Row Fixed-Wide Beam (A)	5% above, 26% below expected distances			
Controllable-Narrow-Beam (B)	38% below expected distances			
Sequence-Flashing (G) and (H)	40% below expected distances			
Slope line (I)	13% above, 16% below expected distances			

NIGHT

25-Candlepower Night Visibility	⅛ mi.	¼ mi.	½ mi.	1 mi.
Expected distance of point of first sight from runway threshold	3300 ft. ± 1000 ft.	3700 ft. ± 1000 ft.	4200 ft. ± 1000 ft.	4800 ft. ± 1000 ft.
All approach lights tested substantially within band of expected distances				

Method of Evaluation

Each approach was evaluated on both the objective data and the subjective comments proffered by the pilots.

The reliability of this evaluation procedure was corroborated by the excellent correlation of the objectively recorded data (*i.e.*, adherence to ideal glide path, lengths of strings of lights carried, etc.) with the comments expressed by the pilot and copilot during and immediately following each approach.

The visual guidance afforded by the approach lights was defined as:

I. "*Successful*" if during the visual approach *all* of the following conditions were fulfilled:

A. Pilot established final visual contact at least 1000 feet from runway threshold without referring back to flight instruments any more frequently than he would under natural visual-flight conditions.

B. Maneuvering was "*safe*" as defined by the following criteria:

1. In *outer half* of region of guidance (>1,500 feet from threshold) any *single* corrective maneuver placed aircraft on substantially straight path within 50 feet right or left (*Y*) and 25 feet above or below (*DZ*) ideal glide path.
2. In *outer half*, any *repeated* oscillation was within a transverse (*Y*-wise) amplitude of 100 feet and a vertical (*Z*-wise) amplitude of 50 feet.

TABLE II.—Minimum Distance of Points of First Sight and Visual Contact, Respectively, for Successful Completion of Approach.

Approach-Light System		Lights First Seen (Copilot)	Visual Contact (Pilot)
Single-Row, (C) & (D)	Day	2500 ft.	2000 ft. GP*
	Night	10000 ft.	5000 ft. GP*
Two-Parallel-Row			
Fixed-Wide-Beam (A)	Day	1900 ft.	1600 ft.
	Night	2100 ft.	1600 ft.
Controll. Narrow-Beam (B)	Day	3900 ft.	2800 ft.
	Night	3200 ft.	2800 ft.
Cont. Sequence Flashing (G)	Day	6350 ft.	3600 ft. GP*
	Night	>10000 ft.	>5000 ft. GP*
Interr. Sequ. Flash. (H)	Day & Night	10000 ft.	5000 ft. GP*
Slope line (I)	Day & Night	1200 ft.	1000 ft.

*GP—Only if a well-defined natural ground plane is visible.

3. In *inner half*, any *single* corrective maneuver had transverse (*Y*-wise) displacement less than 50 feet for any longitudinal (*X*-wise) advance of 500 feet.

C. Aircraft remained within the region of guidance and crossed the runway threshold within 50 feet of the centerline.

D. Touchdown was made or was feasible within the first 2000 feet of the runway.

II. "*Marginal*" if success criteria (*A*), (*B*), (*C*), and (*D*) were satisfied, but the pilot declared any one of the guidance elements "*Y*," "*Z*," and "*direction*" as unsatisfactory.

III. "*Unsuccessful*" if one or more of success criteria (*A*), (*B*), (*C*), and (*D*) were not satisfied, or if the pilot reported any two or more of the guidance elements "*Y*," "*Z*," "*direction*," and "*roll*" as unsatisfactory.

Approach-Light Systems Tested in 1948 and 1949*

Two Parallel Rows, Incandescent Lights, 200 feet apart

A. Fixed wide-beam 5000-w projectors, 100-foot centers; left row red, right yellow.

B. Controllable-beam projectors (toe-in and elevation adjusted to match meteorological visibility) using two 600-w PAR-64 aircraft landing lamps; spacings and colors same as (A). Same configuration also tested with twin units, side-by-side, 11 feet apart.

Single Row, Incandescent Lights, 100 feet left of axis or centered on axis

C. Left-hand row of (B).

D. Axial row 500-w airway course lights, 100-foot centers, red filters.

E. Axial row 14-foot transverse horizontal bars (10 PAR-56 400-w clear lamps per bar), 100-foot spacing. 78-foot transverse bar at 600 feet from threshold; additional units with red filters arranged in box pattern enclosing the threshold (ALPA System).

F. Axial row similar to (E), with units in outer 1000 feet having three spaced-apart pairs of lamps, in middle 1000 feet two spaced-apart pairs of lamps, and in inner 1000 feet four contiguous lamps. Additional transverse bars, 500 feet apart, lamps on 4-foot centers, span of bars tapering from 110 feet at 3000 feet to 50 feet at 500 feet from threshold (Calvert System).

Condenser-Discharge Type Flashing Lights

G. Continual sequence flashing. Single left row, 100-foot centers. Four horizontal neon bars with reflectors in each fixture; every alternate fixture also contained a condenser-discharge lamp, triggered to produce 170-microsecond flashes in sequence from outer to inner end in 1-sec or 0.5-sec cycle, repeating continually. Further, a 1000-foot right row of neon units at inner end.

H. Interrupted sequence flashing. Single left row, lamp spacing varying from 25 feet at outer end to 75 feet near threshold. Alternate lighting units were: (1) a 2-inch krypton flash tube (15-20 microsecond flash) in 25-inch parabolic reflector, and (2) a 24-inch square source consisting of six neon tubes in trough reflectors. Neon sources were either operated continuously (controllable intensity) or flashed on condenser discharge circuits (two values of capacitance). The half-second flashing cycle from outer to inner end was repeated after 1.5-second eclipse.

Slope Line

I. Two rows of 14-foot bars, each bar containing ten 500-w, PAR-64, or 400-w, PAR-56,

TABLE III.—Minimum Length of String of Approach Lights Carried Required for Consistently Successful Completion of Approach. Day & Night.

Approach-Light System	Minimum Length of String of Lights
Single-Row, (C) & (D)	1500 feet, plus definite natural ground plane
Two-Parallel-Row, (A) & (B)	1000 feet
Sequence-Flashing	
Continual-Sequence (G)	1500 feet, plus definite natural ground plane
Interrupted-Sequence (H)	In daylight, at least 2000 feet, plus definite natural ground plane At night, virtually all approaches were unsuccessful, regardless of length of string "carried"
Slope line	500 feet

*For candlepower distributions, flash-time histories, and geometries, see 1948 LAES reports; for geometries of ALPA system, Calvert system, and Garbell system, see 1949 LAES final report.

clear lamps, bars set at 45° in transverse vertical plane, on 100-foot longitudinal spacing, each pair of right and left bars spaced so that their extended axes intersect on instrument glide path. When seen from points of glide path, units appear aligned; system indicates three-dimensional glide path in lieu of establishing two-dimensional extended runway plane.

Slope Line — Transverse Bars

J. A configuration consisting of the two longitudinal rows of slope-line fixtures (45° setting) with a pair of 80-foot transverse horizon bars (400-watt, PAR-56, clear lamps on 4-foot centers) *entirely contained* within the longitudinal rows at 2000 feet from threshold, a similar pair of transverse bars *straddling* the longitudinal rows at 1000 feet, and a similar pair of transverse bars *entirely outside* the longitudinal rows near the threshold, as shown in Fig. 2 (Garbell system, U. S. Patent No. 2,501,504).

Systems (A) through (H), and the transverse bars of system (J) serve to indicate the extended runway plane and were therefore mounted in that plane. The slope-line fixtures of systems (I) and (J) followed the configuration of the local terrain in the approach zone.

Evaluation of Test Findings

Tables I to IV summarize some of the salient findings from the 1948 LAES tests; the 1949 tests were not discussed in detail by Dr. Garbell, as they were still in progress.

Figure 2. The slope-line/transverse-bar (Garbell) system.

Conclusions

The data summarized in Tables I-IV, plus other information obtained at LAES, support the following conclusions:

1. The slope line approach-light system appears to provide the required elements of identification and guidance more effectively than any other approach-light system tested at LAES during 1948.
2. The lower limits of effectiveness of the slope line system, for aircraft having cockpit cut-off comparable to the C-47 (DC-3) type, lie near ⅞ mile object visibility in daylight and one-eighth mile 25-candlepower visibility in darkness.
3. The light coverage within the region of guidance provided by the slope line system is satisfactory. Further improvement could be achieved by selective toe-in and modified angular elevation of some of the individual slope-line lamp units in the outer approach zone.
4. Flashing lights, as tested at LAES during 1948, do not provide sufficient guidance and are not suitable as approach lights.

TABLE IV.—Tabular Evaluation of Approach-Light Systems.

Ratings: G—Good, F—Fair, U—Unsatisfactory, D—Dangerous, N—None

Approach-Light System	Identification	Guidance					Operational Weather Minima With Qualified Instrum. Pilots		
		X	Y	Z	Dir.	Roll		Ceiling	Visibility
Single-Row, (C) & (D)[1]	U	N	U	U	U	N	Day & Night	200 ft.	½ mi.
							With natural ground plane as primary guidance element		
Two-Parallel-Row Fixed-Wide-Beam (A)	U[2]	U	F	U	G	F	Day	75 ft.	¼ mi.
							Night	25 ft.	¼ mi.
Controllable-Narrow-Beam (B)	U[2]	U	F	U	G	F	Day	100 ft.	⅜ mi.
							Night	25 ft.	⅜ mi.
Sequence-Flashing (G) & (H)[3]	Excellent	U	D[4]	U	U	N	Day & Night	200 ft.	½ mi.
							With natural ground plane as primary guidance element		
Slope line (I)	G	U	G	G	G	F	Day	25 ft.	⅛ mi.
							Night	0	⅛ mi.
Calvert system (F)[5]	G	G	G	F	G	G	Day	25 ft.	⅛ mi.
							Night	0	¼ mi.

[1] Center- and left-row systems substantially equivalent to one another.
[2] Color differentiation between rows (red and yellow) occasionally inadequate; yellow lights may be perceived as "red."
[3] Flight-test results with combinations of steady-burning and flashing systems are consistently inferior to those achieved with either system alone.
[4] Pilots reported undesirable stroboscopic and other irritating effects; several approaches in low weather were terminated with pull-outs.
[5] Based on flight tests by LAES pilots and Dr. Garbell at London Heathrow Airport, in visibilities as low as 120 feet, during January 1949.

Comparative Comments on Slope Line and Calvert Systems

In the slope line system, the pilot flies in a dark lane between two parafoveally perceived lines of light bars. If the pilot deviates from a well-centered approach, he is confronted with an intensely bright barrier of staggered lights serving as a forceful warning.

In the Calvert system, the pilot flies ideally along and above a centerline of lights. If, in an excessive corrective maneuver, the pilot inadvertently crosses the centerline of the Calvert system, he may — without any further warning — find himself with all effective visual aids *behind him;* hence, a pull-up may be unavoidable.

The slope-line system affords good elevation, transverse, and direction guidance; its bank guidance is only fair, *X*-wise guidance is inadequate.

The Calvert system provides good direction-and-bank guidance as well as adequate *X*-wise guidance so long as the aircraft enters the system well centered; elevation guidance is provided in spurts and is only moderately effective.

Garbell System

The transverse horizon bars in the Garbell system afford excellent roll guidance and, hence, improved directional guidance. The transverse location of the transverse bars with respect to the two slope line rows—with the 2000-foot bars contained entirely within the slope line rows, the 1000-foot bars straddling the slope line rows, and the threshold bars placed entirely outside the slope line rows (thereby forming a characteristic "gate" at the runway threshold)—affords instantaneous *X*-wise distance guidance without any need for numerical counting of coded lights used in other systems.

The characteristic intersection of the transverse bars with either slope line row, at an angle of approximately 45°, also serves to quicken the identification of the respective slope line rows in the mind of a pilot who might at first see only one slope line row.

The effectiveness of the system has already become so evident that, in the Fall of 1949, the CAA granted permission to a scheduled air carrier (Southwest Airways at Arcata, Calif.) to lower its natural weather minimums to a 100-foot ceiling and a quarter-mile visibility, provided that the slope-line/transverse-bar (Garbell) system is used. This operation has been entirely successful and has eliminated completely the need for costly fog dispersal by means of gasoline burners. Another such installation is operational at the Los Angeles International Airport; an experimental installation at the Weir-Cook Airport in Indianapolis was inspected in flight by the I.E.S. Aviation Lighting Committee after the presentation of Dr. Garbell's paper.

Cockpit Cut-Off

The guidance afforded by approach lights is, naturally, greatly affected by the external visual field out of an aircraft cockpit, which is a function of the size of the windshield, blocking by instruments, and the position of other structure ahead of the pilot. This limitation of the pilot's visual field usually is termed "cockpit cut-off."

A review of the LAES test results indicates the extreme importance of adequate cockpit visibility in enabling the pilot to utilize the full visual guidance afforded him by the approach lights.

A cockpit visibility at least equal to that of the DC-3 or the Convair-240 aircraft is essential to ensure safe approaches on approach lights alone, that is, when the natural ground plane is not visible to the pilot.

Agriculture Student Explains the Footcandle

The footcandle is a wonderful animal. Unlike the foot-pound, to which it is wholly unrelated, the footcandle can have only *one* foot and *one* candle whereas the foot-pound can have any number of feet *N* so long as it has one *N*th of a pound. This makes the footcandle easily misunderstood except sometimes by footcandle breeders, commonly known in the vernacular as "illuminating engineers."

Footcandles tend to breed white, but by mutations of various kinds, red, green, blue, etc. are readily produced. Red and blue footcandles have much more energy than white (and green much less) but people are unaware of this through visual reaction alone.

A footcandle can exist only among human beings but is never seen by them unless created on a human retina. A footcandle brightens up whatever it hits, including people, but not indiscriminately. It makes people who *reflect more* seem to others much brighter than those not struck by a footcandle. Footcandles bounce off some surfaces and are devoured by others but usually both of them happen in various proportions. Surfaces giving more bounce are called "good reflectors."

A bounced footcandle has no existence until it is again intercepted, when it usually will be found smaller or larger than before. Some surfaces (called "diffuse") kick a footcandle into smithereens all over the place and one footcandle so upset seldom ever all by itself becomes collected enough to make anything very bright.

It is very hard to understand a footcandle.

(Contributed by Prof. E. M. Strong, Cornell University)

Lighting a Hallway

LIGHTING OBJECTIVE: To provide a low level of illumination for general lighting and to accent the scenic wall paper that is the decorative note of interest in the hall.

Installation in residence of Mr. and Mrs. A. Brasch, Detroit, Michigan; architect: Frank Barcus, Detroit, Michigan.

General Information: The hallway is 14 feet 2 inches by 10 feet 2 inches. It is located in the center of the house and provides entrance to the dining room, living room, library and stairway to the second floor. The 7½-foot ceiling is light gray in color (reflection factor 66%); the woodwork and shuttered doors are white (reflection factor 85%). The scenic wall paper covers one entire wall and is done in shades of full white through gray to black. Vivid green carpeting is used on the stairway, the flagstone flooring is in a varicolored pattern of deep green, red and black, and the chair cushions are of a bright floral design in green, yellow and rose.

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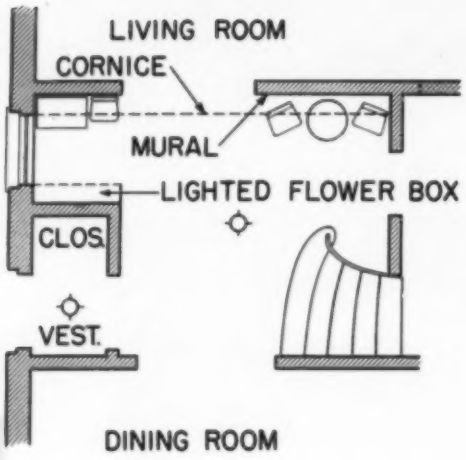

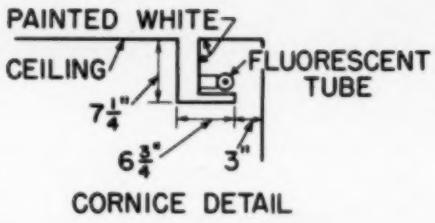

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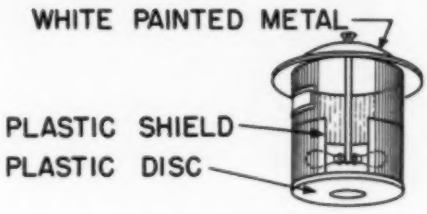

Installation: Three 40-watt fluorescent tubes in a continuous row are concealed by the wall to wall bottom-shielded plaster cornice. The ballasts are located in the basement. The ceiling fixture, originally a bird cage, was painted white and wired for three 25-watt filament lamps. A plastic disk fits into the bottom of the cage and a five-inch deep plastic side shield provides excellent light diffusion and eliminates direct viewing of lamp bulbs from any position on the stairway.

Average hallway illumination is 5 footcandles. Brightnesses are as follows.

Plastic shield on ceiling fixture	50.0 Footlamberts
Circle of light on ceiling above fixture	18.7 "
Dark gray of wall paper	2.0 "
Top of wall paper, beneath cornice	62.5 "

Lighting data submitted by Mary Taepke, The Detroit Edison Company, Detroit, Michigan, as an illustration of good lighting practice and to aid in the design of similar installations.

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Lighting Projection Screen Surroundings

By JAMES R. CRAVATH

SOME TIME ago I sat through two meeting of lighting men, arranged by lighting specialists, supposedly well acquainted with the art. Many projected pictures were used. The conditions during picture projection were decidedly uncomfortable, obviously due to the great contrasts of brightness between the pictures on the screen and their surroundings. At that time, 1947, our knowledge of comfortable brightness conditions in interiors had been sufficiently settled to be stated in our committee reports on recommended practice.[8] How did these recommendations apply here? What engineering data were there applying to methods of avoiding too much brightness contrast between screen and surroundings? A search of the *I.E.S. Transactions* gave almost nothing, which seemed strange, and moved the writer to a further search in technical literature, some study of the subject and a few tests to aid in an engineering analysis. The results were put on record in a lengthy informal memorandum, available for reference in the I.E.S. files, of which the following is a very condensed summary with some corrections and additions

Comfortable lighting when projected pictures are shown affects millions of people today in civilized and semi-civilized countries. The projected picture has thoroughly permeated the world of education and amusement. Inspection of the appended bibliography shows that study of this subject has been largely confined to the motion picture engineers.

Definitions and Nomenclature

Since confusion of nomenclature existed, a certain amount of standardization of terms in this article seemed desirable, as follows:

Non-projected light. Light reaching the screen or its surroundings, other than that projected from the picture projector; otherwise called general lighting, stray light, spilled light, house lighting, secondary lighting, etc.

Screen brightness. The brightness of the screen when no film or slide is interposed and, in the case of moving picture projectors, with the shutter operating.

Picture brightness. The mean or integrated brightness of substantially all the points on a slide or film picture as it appears on the screen at any instant. This term as used here does not seem to have been used in the literature of the subject here listed, previous to 1948. I have recently been using it to express the brightness obtained by multiplying the screen brightness by the transmission of the slide or film; the transmission having been determined by laying the slide on the test plate of a photoelectric photometer. Recently Logan[12] has used a flux meter with a photoelectric cell pointed at the moving picture screen and drawing a continuous curve of picture brightness with the film running; which curve averaged for a given film he terms the "average screen brightness."

Screen surroundings as herein used will mean the area within the visual field of observers, but especially that within the central field.

Presentation of data. Ability to compare easily brightness ratio data being essential to such a study of this subject as is here attempted. All figures obtained from the various references will be, if possible, corrected to what they would be with a screen brightness of 10 footlamberts. Incidentally that is the screen brightness recommended as standard practice for movie theaters by the S.M.P.E.[9]

The natural action of novices is to darken the room for projected pictures as much as possible. When the motion picture industry began to assume importance this natural tendency to extreme darkness in theaters began to be modified. Patrons had difficulty in finding seats in the dark, and there were complaints about eye strain due to brightness differences between the pictures and the excessively darkened room. This started studies of the subject in the motion picture field that have now been going on for the past 30 years. (See bibliography.) Study of the references shows conclusions by various investigating committees and laboratories from visual appraisals made by committee members and laboratory employees. As such visual tests by the public are the court of last resort, these preliminary trials by a few are of great im-

The author is a Member Emeritus, I.E.S., now retired and living at 2152 Ward St., Berkeley 5, Calif.

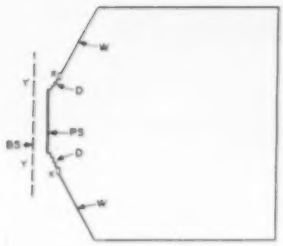

Figure 1.

Figure 2.

portance. Unfortunately while many of these conclusions have value as approximate guides in conditions of current practice, they lack in many cases, some necessary factors to make them available for comparison with each other, or confusion of nomenclature makes meanings uncertain.

The following methods of lighting the surroundings of projection screens have come to my attention.

Method A, the simplest and commonest, is to use the general lighting. Since whatever of this falling on the screen brightens the dark areas of the picture and reduces the brightness contrasts of the picture, this method is limited to the amount of such reduction that is tolerable. The only definite information on such tolerance limits to be found among the numerous researches reported in the references is .88 footlambert for "serious harm" to the picture and .45 "still objectionable" (corrected to a 10-footlambert screen brightness) found by Falge and Riddle[2] at Nela Park from visual tests by a number of observers. The real tolerance limit for general application must be considerably lower. This tolerance limit necessarily varies over a wide range with the differing pictures. Pictures of high contrast such as black and white line drawings and some rather contrasty photographs may be acceptable with as much as one footlambert non-projected light on the screen, in my experience. With pictures of low contrasts, calculations show that the non-projected light probably may have to be as low as .02 footlambert. The method of such calculation is omitted here for lack of space. It involves a knowledge (or assumptions) as to the contrasts of the picture film or slide and the contrast sensitivity of the least sensitive people in the audience (individuals vary) at the illumination (adaptation level) existing. An informal survey of five movie theaters with a brightness meter showed brightness levels of .025 to .005 footlambert for screen surroundings, of which a large part was not from the picture. Theaters of Types 1 and 2 (described later) were included. These figures are probably typical of general practice in the United States.

Method B. Shown in Fig. 3. *PS* is the picture screen; *X* a luminaire behind it which should light the back wall as uniformly as possible. This sounds simple but is really not easy because many in the audience can see the wall *BS* part way behind the

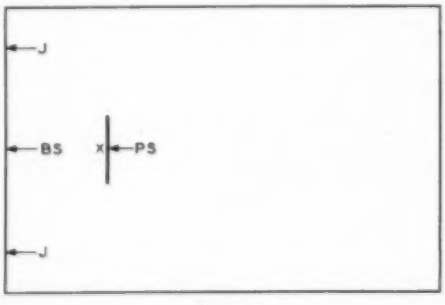

Figure 3.

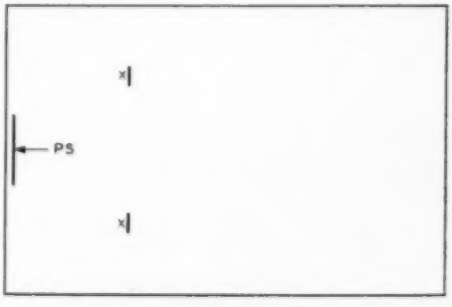

Figure 4.

screen and to provide uniformity of brightness on this wall from *X* involves some very special equipment.

Method C. Shown in Figs. 1 and 2, where the screen *PS* has the usual draperies at *DD* removed. Light sources at *XX* light a background *BS* so that the brightness of the immediate screen surroundings can be made anything desired without appreciably increasing the non-projected light on the picture.

Method D. A modification of *C*. *PS* is translucent enough to light the back screen *BS* as seen through the open spaces *DD*.

Method E. Paint the screen surroundings with luminescent paint and direct ultraviolet rays on them from sources concealed from the audience, as in Fig. 4.

Method F. Light the surroundings by light from the picture screen, thus tending to keep the brightness ratio of picture to surroundings more nearly constant than with other methods. This is extensively used in theaters, both by intention and unwittingly as incidental to a room design suited to most favorable screen viewing angles. It is most effective in rooms shaped like Figs. 2 and 5 where the surfaces *WW* are at a better angle for reflecting screen brightness than in Fig. 1. The automatic compensation which this helps to give for the great variations in picture brightness is important. It is the only method of those here listed which does this.

Method G. Use back-of-screen projection onto a translucent screen. Not a remedy for excessive contrasts in itself but makes possible more non-projected light on the screen than with ordinary projection because more of the non-projected light goes through the screen than with front-of-the-screen projection.

Method H. A refinement and simplification of some of the previously enumerated methods is shown in Fig. 5. There is no stage or proscenium opening. Sources behind the screen light the immediate surroundings independently of the general non-projected light in the room. The walls *WW* are lighted mainly by the light reflected from the picture and (except for the non-projected light from the rest of the room) vary automatically with the picture brightness. Thus in a simple way many of the best features of the previously enumerated methods are combined.

Figure 5.

Shapes of Rooms

Shapes of rooms in which pictures are most commonly projected are shown in Figs. 1 to 5, and have been partly described under "Methods."

Fig. 1 is the old combination stage show and motion picture theater. Of significance here is the "blunt wedge" shape formed by the drapes *DD* and walls *WW*, which is not favorable to lighting the screen surroundings from the picture.

Fig. 2. The "long wedge" shape is more favorable to varying the lighting of the picture surroundings automatically from the picture screen, and is also more favorable than Fig. 1 for picture viewing at favorable angles from the extreme side seats.

Figs. 3 and 4 are common types of lecture and assembly rooms.

Fig. 5 is one of the most recent motion picture theater designs, by Schlanger,[13] planned for good seeing of pictures by avoiding the necessity of part of the audience viewing pictures too remote from normal to the screen and for avoiding excessive brightness contrasts between screen and surroundings.

Ideal brightness ratios for surroundings to "task" (or in this case surroundings to picture) now recommended by our I.E.S. committee[8] for ordinary indoor tasks would be from 1:1 to 1:3. Attempts to attain such ideals by experiments with projected pictures in a small assembly room like Fig. 3, together with visits to a number of movie theaters with a brightness meter, brought out certain difficulties in the way of attaining the ideal that some critics of movie theater practice in the past have apparently overlooked. These difficulties are in the great variations in picture brightness of the pictures shown from time to time.

As the picture is the task in this case, it is obviously necessary to know the brightness of the task before we can plan a proper surrounding brightness. Assuming that the picture brightness as herein defined should be considered the brightness of the task, typical slides were tested by the writer for transmission, by laying them on the test plate of a footcandle meter. Logan[12] also uses picture brightness as a basis for estimating desirable surrounding brightness.

Table I shows my own results reduced to footlamberts picture brightness with 10-footlambert screen brightness: that is, 10 × the transmission factor.

TABLE I.—Footlamberts Picture Brightness for Typical Slides, Calculated from Transmission Tests by Cravath. For 10-Footlambert Screen Brightness.

Kind of Slide	Footlamberts Picture Brightness
Black and white line drawing, curves	8.3
" " " " " "	7.1
" " " photo of machinery, indoors	2.3
" " " photo of factory interior	1.9
Kodachrome, outdoor photograph	.86
" " " "	.62
" " " "	.59
" " " "	.49
" " " "	.46
" " " "	.38

TABLE II.—Average Motion Picture Brightness of Various Films Found by Logan, as Reduced to a Common Basis of 10 Footlamberts Screen Brightness.

Kind of Film	Footlamberts Picture Brightness	
	Maximum	Minimum
Black and white news	1.67	.23
" " " feature	3.40	.03
" " " news	3.09	.19
Cine color short	1.79	.35
Technicolor feature	5.63	.18
" travelog	2.47	.80
Self colored, animated cartoon	4.73	.36
" " " "	3.93	.35

Table II shows Logan's results[12] with a flux meter pointed at the moving pictures, as reduced to a 10-footlambert screen brightness.

Most striking in these tables is the maximum picture brightness of 8.3 compared to .03 minimum. However, as the .03 stands apart as perhaps a freakish figure, suppose we take the next highest, which is .18. Then an ideal surrounding brightness for the brightest picture would have to be 8.3/.18 or 46 times brighter than for the darkest. This brings out forcibly the importance of automatically varying the surrounding brightness as much as feasible, though far from the ideal, as in Methods *F* and *H* and as in some of the most recent theater designs, and as advocated by Schlanger.[7]

For projected pictures in rooms technically designed for the purpose, future advances will probably be along the lines just indicated. More data are desirable as to the amount of non-projected light permissible on a screen with various kinds of pictures from visual tests with a larger number of observers. It is unsafe to depend on present knowledge to determine this by theoretical calculation.

It is conceivable that in the future the synchronous control of screen surrounding brightnesses may be carried further than at present technically feasible. Perhaps, have we sufficient latitude it can be overdone. Combinations of the various methods herein outlined also merit future study.

For the occasional users of projected pictures in rooms not specially designed for such showings, not much can be suggested beyond the rough and ready rule to darken the room no more than found absolutely necessary by trial and experience to bring out the least contrasty pictures to be shown.

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Sequence-Start Series Ballasts For Instant-Start Fluorescent Lamps

By HANS U. HJERMSTAD

Ballasts to operate two instant-start slimline lamps in series have been on the market for a little over two years. Three basic types have been brought out during this period. This paper describes the operating characteristics of the lead-lag ballast and each type of sequence start series ballast.

BALLASTS are devices which, by means of inductance, capacitance, or resistance, singly or in combination, limit the lamp current of a fluorescent lamp to the required value for proper operation. They also, where necessary, provide the required starting voltage and current. In many instances, radio interference suppression capacitors, capacitors for power-factor correction, and capacitor discharge resistors may form a part of such ballasts.[1]

In the early types of fluorescent lamps a ballast was usually used in conjunction with a starter. The function of the ballast was to provide the normal operating voltage and current for the lamp. By means of the starter with a ballast a transient could be set up, since it was a momentary interrupting device to produce sufficient instantaneous peak voltage that would cause the lamp to strike or ionize. With the advent of the instant-start and slimline type of lamp, several circuits were designed to provide instant-starting[2] and at various operating currents. Most of these were similar to the original preheat type of ballast except that they provided sufficient starting voltage to ignite the lamp without the aid of the starter.

When the 96T8 lamp grew into a 96T12 lamp the size of the ballast also grew — the original ones weighing in the neighborhood of 23 pounds. The wattage loss of these early ballasts was indeed very high, often times being as high as 60 watts to energize two 75-watt or 96T12 lamps. This in comparison to the normal 18 to 20 watts loss for two 40-watt preheat lamps made the overall efficiency of the slimline lamp very low.

Lead-Lag Ballasts

Most of the lead-lag ballasts that have been designed for the slimline lamps are similar to that shown in Fig. 1. They consist of an auto-winding of the primary and secondary of a power transformer. The output of this transformer is fed through a reactance L_1 to form an impedance in series with lamp No. 1 which limits the lamp operating current to its nominal value at rated line voltage. Lamp No. 2 is fed through a choke L_2 and a capacitance C_1 from the same power transformer. R_1 is a discharge resistor for C_1. In other words, the power transformer acts as the source of voltage and energy. This power transformer then must be capable of supplying the normal open-circuit voltage of the lamps. The function of L_1 is to form a means of limiting the energy to lamp No. 1 and to take up the difference in voltage between the normal operating voltage of the lamp and its starting voltage. Since the circuit of lamp No. 1 has been highly inductive, the power-factor of this circuit will be lagging. Hence, this is often referred to as the lag side of the ballast. In order to correct for this power-factor condition, L_2 has had C_1 placed in series with it. C_1 is of such size as to provide nearly unity power factor in the primary circuit. This side of the ballast is commonly referred to as

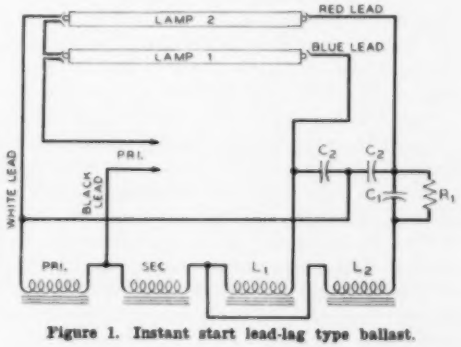


Figure 1. Instant start lead-lag type ballast.

Author: Assistant to the President, Sola Electric Co., Chicago, Ill.

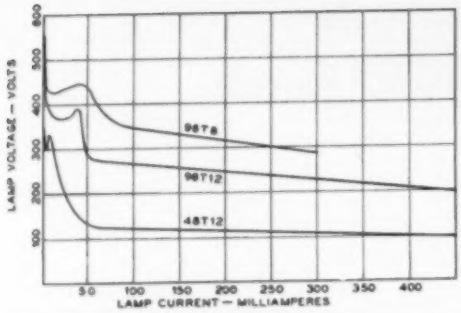


Figure 2. Static instant start single-pin lamp characteristics.

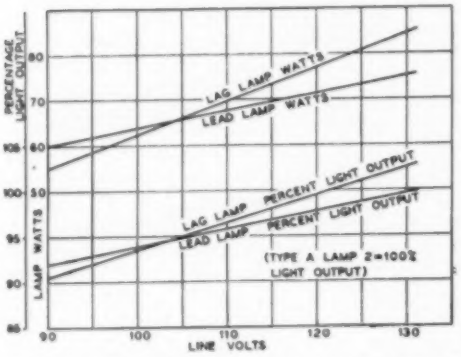


Figure 3. Output characteristics of a normal lead-lag type ballast for two 96T12 lamps.

the lead side, since the current in this leg of the ballast is substantially leading. The current in lamp No. 2 now is leading the current in lamp No. 1. The light output of both lamp 1 and lamp 2 will have less stroboscopic effect than if both lamps had been operating from a lag circuit. Since there is such a large difference in operating voltage to striking voltage of instant-start lamps, L_1 and L_2 will be called upon to dissipate a considerable amount of energy. This results in their physical size being large in order to dissipate the necessary watts.

Fig. 2 shows a group of static characteristic curves for the 96T8, 96T12 and 48T12 instant-start lamps. A.S.A. ballast requirements for the minimum necessary starting voltages are in excess of those shown on the typical static characteristic curves. Minimum ballast starting voltage for the 96T8, is 675 volts; for a 96T12, it is 565 volts and 385 volts for the 48T12 at any range of line voltage from 106 to 130 volts.

In order that this new instant-start T-12 type of lamp would be practical, it became obvious that there was a need for a different type of ballast and the objectives were to reduce: high watt loss; temperature rise;[3] physical size; weight; noise; the variation in Light Output with the Primary Voltage[4] (See Fig. 3); cost.

Sequence-Start Series—Type A

With these in mind as design factors, a sequence-start series type of ballast was developed and made available late in 1948. One of these ballasts for operating two 96T12 lamps is shown in Fig. 4 and will be referred to as "Type A." A basic schematic diagram is shown in Fig. 4A. This unit is a high reactance transformer in which the primary and secondary have been connected as an auto-winding. The output voltage of the transformer is such as to provide a voltage slightly higher than that required for one lamp. The transformer, being of the high reactance type, limits the amount of energy that it can deliver to the lamp circuit. A capacitor C_1 is placed in series with the secondary and is of such size as to correct the power factor of the load. The value of capacitance is such that the inductance of the primary and secondary in series with the capacitor C_1 will bring about a resonance effect. Capacitor C_2 and Resistor R_1 form a shunt impedance across lamp No. 2 and their purpose is to provide the starting voltage of lamp No. 2, once lamp No. 1 has become conductive, as well as providing the initial starting current of lamp No. 1. C_3 is a capacitor placed across lamp No. 1, to dampen any RF oscillation that may be caused by the lamp in the form of radio interference. Naturally C_2 will take on this function for lamp No. 2. R_2 is a discharge resistor to discharge the capacitor C_1 in the event that lamp No. 1 should be removed from the circuit.

The actual diagram of connections is shown in the schematic as Fig. 4B. In order to understand the starting sequence the basic schematic diagram of 4A has been broken down into three sets as shown in Figs. 4C, 4D and 4E.

Referring to the Fig. 4C, the open circuit voltage E_1 is placed across lamp No. 1 in series with C_1, R_1 and C_2. The voltage applied across lamp No. 1 is approximately 700 volts and causes lamp No. 1 to ionize. The current path is through C_1 lamp No. 1, C_2 and R_1. This current then causes a voltage E_2 to appear across the parallel impedance of lamp No. 2 (see Fig. 4D). The current ranges from 65 to 85 milliamperes depending upon the lamp and other circuit constants. The moment lamp No. 1 became conductive in Fig. 4C, the voltage

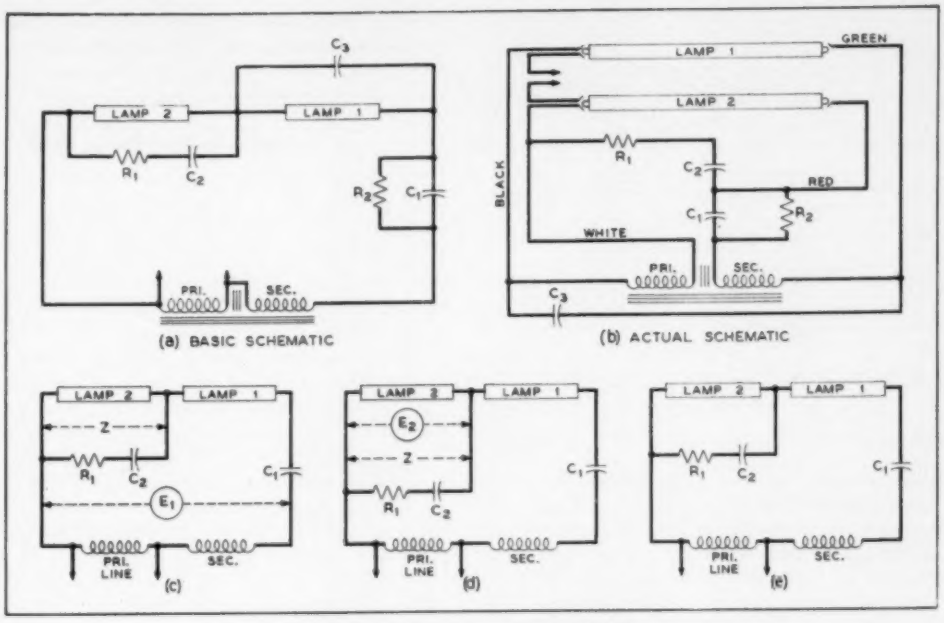


Figure 4. Type "A" sequence-start series ballast.

appearing across lamp No. 1 was reduced from 700 to approximately 280 volts. Referring to Fig. 2, it can be seen that the 96T12 has a voltage of approximately 280 volts at 65 to 85 milliamperes. Due to the voltage E_2 and energy existing in the impedance path Z, lamp No. 2 ionizes with a current sufficiently large to cause lamp No. 2 voltage to drop. The moment the combination of the lamp voltages is less than the voltage of the supply source, the two lamps will operate in series. The current then increases to its nominal operating value, limited by the reactance of the ballast circuit. Under these conditions the reactive components of the inductance of the primary and secondary of the transformer and the capacitance C_1 are such that the ballast operates at a resonant condition and the wattage to the lamps remains nearly constant over a wide range of primary voltage. Since the circuit is operating at resonance, the power factor appears on the primary side as nearly unity. Once lamp No. 2 has become conductive, the parallel impedance of Z is so high by comparison to the lamp resistance that very little energy is dissipated in the shunt circuit. This does, however, show up in the form of a difference of watts to each lamp and is best illustrated by Fig. 5 in which lamp wattage and percentage of light output are plotted against variation of primary voltage. The light output from lamp No. 2 is used as a reference level and called 100 per cent.

The construction of the core and coil of type "A" sequence-start ballast employs a relatively small amount of copper and iron. As a result of this, the losses have been materially reduced, the efficiency is improved and the temperature rise of the ballast reduced. The ballast losses for two 96T12 lamps now are lower proportionately than that of a ballast for two 40-watt preheat lamps. In the case of the sequence-start ballast for the 48T12 instant-start lamp ballast, it has been possible to provide a ballast in which the watts loss is comparable to that of a preheat type circuit. In addition, its dimensions are such that its mounting centers are equivalent to the ordinary brick-type ballast. The mechanical and electrical designs of ballasts for the 96T12 and 48T12 lamps are quite comparable; they consist of a center core or leg sometimes referred to as an "I" piece which is forced into the outside leg upon assembly. The outside leg is then called upon to serve a dual purpose — first, to act as a magnetic path and secondly, to provide a means of holding the center leg tight and free from vibrations and noise. The entire assembly then is clamped together by means of rivets to hold the

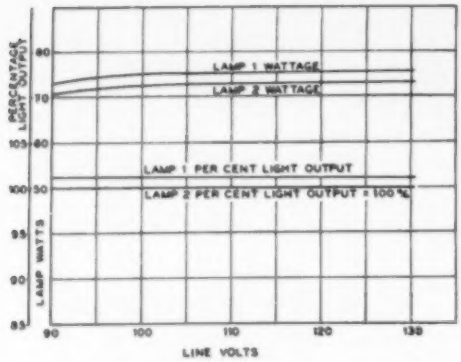


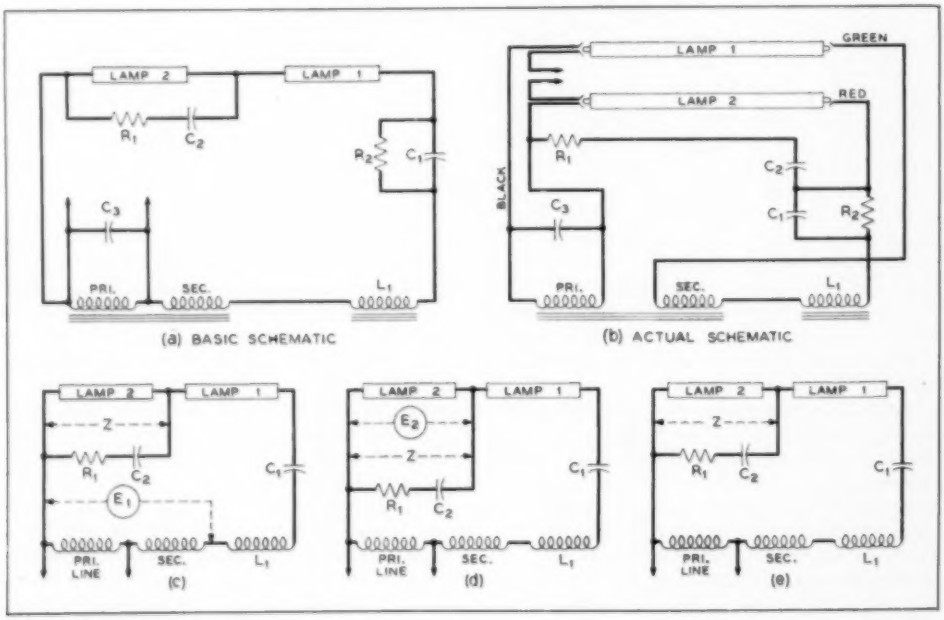
Figure 5. Output characteristics of Type "A" ballast for two 96T12 lamps.

core structure. The core and coil assembly of the ballast for 96T12 obtains its leakage reactance by means of its relative length, whereas the ballast for 48T12 gets its high reactance by a magnetic shunt between the primary and the secondary and the size of the airgap limits the amount of energy to be delivered to the secondary of the transformer. An interesting feature is that the outside legs are larger than the center leg; consequently the flux density is reduced around the outside magnetic path. This cuts down noises generated in luminaires due to excessive stray flux.

Sequence-Start Series—Type B

The second type of sequence-start series ballast to be discussed will be designated as type "B" and is shown in Fig. 6. The basic schematic diagram is shown in Fig. 6A and the actual diagram of the connections used internally in the transformer is shown in Fig. 6B. The ballast consists of an autowinding of the primary and secondary of a power transformer. In series with the secondary as shown in Fig. 6A is placed an inductance L_1. This inductance is used as a limiting inductance or impedance to limit the amount of energy to the lamps No. 1 and No. 2 when in operation. Capacitance C_1 is placed in series with inductance L_1 and the inductances of the primary and secondary to provide the means of power factor correction. Resistance R_2 is placed across capacitance C_1 to act as a capacitor discharge resistor. Across lamp No. 2 is placed a capacitor C_2 and a resistor R_1 to form a shunt impedance. In some sequence or series ballasts R_1 has been omitted and just a condenser

Figure 6. Type "B" sequence-start series ballast.



placed across lamp No. 2. C_3 is a capacitor placed across the primary of the transformer to prevent any radio interference feeding back into the power line.

In sequence of opeation, the device is very similar to the type "A." Referring to Fig. 6C, an open circuit voltage E_1, is developed across the primary and secondary of the transformer and in turn appears across the terminals of the lamp No. 1 through the shunt impedance Z and the series capacitance C_1. The open circuit voltage E_1 is so high that immediately upon energizing the primary, lamp No. 1 strikes and the current is limited by L_1, C_1, C_2, and R_1. The initial current through lamp No. 1 is such that the cathodes of lamp No. 1 are brought up to emission and the tube voltage drops. Z and C_1 allow a current of approximately 65 milliamperes to flow through the lamp No. 1. This value of current through the shunt impedance Z causes a voltage E_2 (Fig. 6D) to be established across Z, which is of such magnitude as to cause lamp No. 2 to ignite. As soon as the drop in lamp No. 2 becomes stable (see static characteristic curve as shown in Fig. 2) both lamps are then in series and they come up to full operating current, limited then by L_1 and C_1. Z is so high that only a few milliamperes of current are shunted around lamp No. 2. The output characteristics of this ballast are plotted in Fig. 7 to show the lamps watts and the percentage of light output of each lamp against the variation in primary voltage.

The assembly of the primary, secondary and the inductance, L_1 is made in a very unique manner. The core is made up of a group of "E" shaped laminations. The primary and secondary are placed over open ends of the "E's," and the outside legs are welded together at the edge of the butted "E's." Similarly the magnetic path for L_1 and its gap to form an inductance is made on another set of "E's" which in turn are butted against the outside leg of the primary and secondary transformer core, and in turn are welded.

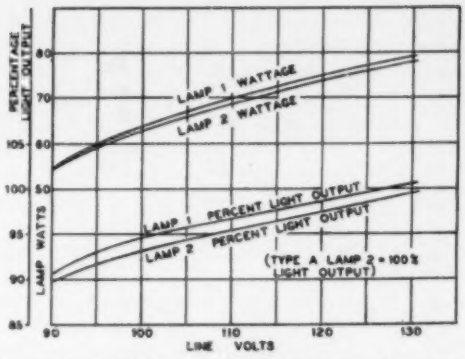


Figure 7. Output characteristics of Type "B" ballast for two 96T12 lamps.

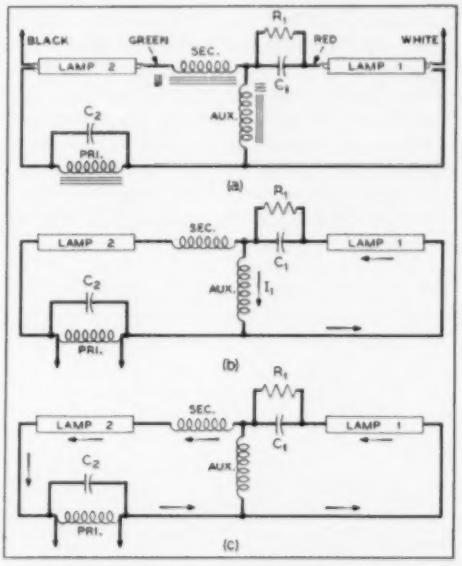


Figure 8. Type "C" sequence-start series ballast.

Type C

The type "C" sequence-start series ballast is shown in Fig. 8 and starts in quite a different manner than types "A" and "B." The ballast consists of a primary, a loosely coupled secondary to constitute a high reactance transformer and an auxiliary coil very loosely coupled to the primary. The capacitor C_1 is used for starting and power-factor correction. A resistor, R_1 is used for a capacitor discharge resistor and a capacitor, C_2 is placed across the primary for radio interference suppression. Referring to Fig. 8B, when the primary of the ballast is energized and before either lamp strikes, the voltage applied across lamp No. 1 is the auxiliary winding voltage and the voltage across lamp No. 2 is the vector sum of primary, auxiliary and secondary voltages. The phase relationship of primary, auxiliary and secondary windings is such that the primary and secondary voltages oppose the auxiliary winding voltage. This results in a lamp No. 2 voltage of approximately 210 volts, much too low to strike the lamp. However, the auxiliary winding voltage which is directly across lamp No. 1 is approximately 700 volts,

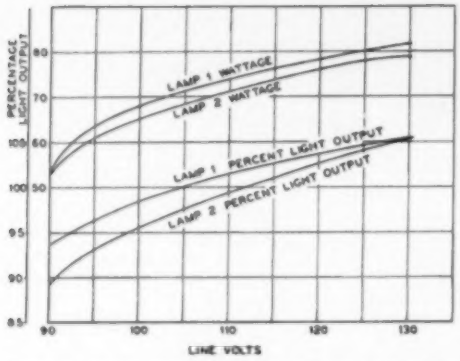


Figure 9. Output characteristics of Type "C" ballast for two 96T12 lamps.

sufficiently large to strike the lamp. At this stage, lamp No. 1 operates at only partial brilliance due to the high reactance of the auxiliary winding. The current path at that particular time is through lamp No. 1, through the condenser C_1 and the auxiliary winding which is the supply source. As soon as lamp No. 1 is conducting, however, capacitance C_1 shifts the phase angle of the auxiliary voltage (due to the auxiliary coil being a portion of the common magnetic circuit) so that it now adds to the primary and secondary winding voltages. This causes the voltage across lamp No. 2 to rise to approximately 685 volts which is ample for starting. Now that both lamps are conducting, the main current path is that shown by the arrows in Fig. 8C. The auxiliary winding impedance is so great in comparison to the balance of the circuit that very little current flows through the auxiliary winding. In fact, the auxiliary winding circuit can be opened and both lamps will continue to operate, (the same as the shunt circuits in types "A" and "B"). Lamp No. 1 is now in series with capacitor C_1, the secondary of the high reactance transformer, lamp No. 2 and the primary. The normal reactance of the transformer limits the current to both lamps and C_1 is used as a power correcting capacitor as in the cases of types "A" and "B." The output characteristics of the transformer both in watts and light output are shown in Fig. 9.

The three sequence-start ballasts described have all been for use with the 96T12 lamps. Ballasts are available, however, for other sizes of lamps such as the 48T12 in the type "A" and "C" construction.

A summary of the operating characteristics of the lead-lag and the three designs of sequence-start ballasts for the 96T12 lamps is given in Table I.

Sequence-start ballasts for operation of 48T12 lamps for cold weather operation are available in which the output voltages of the ballasts are higher than that normally required for indoor use. In addition to having the higher voltage available, they have been equipped with special low temperature type capacitors for starting and power factor correction. Fig. 10 shows a photographic compari-

TABLE I.—Typical Operating Characteristics for Ballasts for Two 96T12 Lamps.

	Lead-Lag Type	Type A	Type B	Type C
Wattage Loss — Watts*	47.8	31.4	38.4	32.5
Primary Current — Amperes*	1.73	1.64	1.70	1.61
Open Circuit Voltage — Volts*				
Lamp 1 in Series Circuit — Lag Lamp in Lead-Lag Circuit	622	705	655	705
Lamp 2 in Series Circuit — Lead Lamp in Lead-Lag Circuit	610	603	590	638
Lamp Current — Milliamperes*				
Lamp 1 in Series Circuit — Lag Lamp in Lead-Lag Circuit	449	469	465	441
Lamp 2 in Series Circuit — Lead Lamp in Lead-Lag Circuit	410	462	470	474
Lamp Wattage*				
Lamp 1 in Series Circuit — Lag Lamp in Lead-Lag Circuit	74.6	75.4	75.2	74.8
Lamp 2 in Series Circuit — Lead Lamp in Lead-Lag Circuit	69.6	73.2	74.4	76.7
Starting Current in Lamp 1 of Series Circuit — Milliamperes*	——	67	68	145
Peak/RMS Ratio of Lamp Current*				
Lamp 1 in Series Circuit — Lag Lamp in Lead-Lag Circuit	1.45	1.76	1.58	1.50
Lamp 2 in Series Circuit — Lead Lamp in Lead-Lag Circuit	1.43	1.81	1.61	1.51
Primary Coil Heat Rise, by Resistance — Degrees C*	52.9	35.9	62.4	57.8
Heat Rise of Point on Condenser Adjacent to Core & Coil — Degrees C*	30.2	18	22.4	31.2
Efficiency — Per Cent*	74.8	82.3	79.6	82.4
Light Output Variation — Line Voltage from 90V-130V — Per Cent	11.9	0	11.3	15.1
Weight, Pounds	19½	11½	12½	10¾
Size, Cubic Inches	150	102	108	80

*Line Voltage E, 118 Volts.
Tests on ballasts produced December 1950.

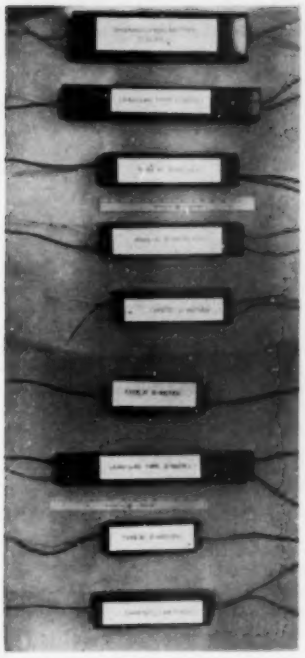


Figure 10. A photographic comparison of the sizes of the lead-lag ballasts and the sequence-start series types. Top to bottom: Original lead-lag type, 2-96T12; lead-lag type, 2-96T12; Type "A," 2-96T12; Type "B," 2-96T12; Type "C," 2-96T12; Type "A," 2-96T8; lead-lag type 2-96T8; Type "A," 2-48T12; Type "C," 2-48T12.

son of the sizes of the lead-lag ballasts and the sequence-start series types.

There has been a great deal of discussion about the lack of stroboscopic correction in the sequence-start ballasts. Since both lamps are in series, the phase difference between the two lamps is nil because the shunt circuit has little effect on the lamp when operating at rated current. Upon checking this type of ballast for "strobe," however, it was found to be equivalent in performance to many of the lead-lag ballasts. No doubt the amount of apparent "strobe" has been greatly reduced by the longer lag phosphors. More "strobe" is apparent on the colder white colors than the warmer colors. Fig. 11 shows pictorially the effect of "strobe" in a series of photographs taken at F-22 with a one-second exposure (the light source went on and off 120 times) using black and white film with an A.S.A. Index of 50. Two 48T12 cool white, 4500° lamps were used as a light source and placed 8½ inches apart on center line and 13¼ inches from the rotating turn-table. A stroboscope disc which had been designed to check on the operating speeds of 78.26 rpm. phonograph turn-tables was used as the source of motion. The lines on the disc are designed to creep in either direction when the speed is incorrect when viewed under a neon or fluorescent light source operated at 60 cycles. The speed of the rotating disc was adjusted to 78.26 rpm so that no creep existed. The amount of strobe is indicated by the comparative darkness and sharpness of the lines of the test circle which is in synchronization with the light source. Fig. 11A is an exposure of what would appear with a truly stroboscopic light source. For our comparison, however, it is the same one-second exposure as exhibits 11 B, C, and D, except that the strobe disc is stationary. In Fig. 11B the lamps were powered by a ballast of the lead-lag type having good power factor correction, in Fig 11C by a ballast of type "C," in Fig. 11D by a ballast of type "A" construction. Note the variation in the gradation of darkness and sharpness of the lines. It appears that the lead-lag has slightly less "strobe" than the types "A" and "C" but the difference is so small that except for movements at exact synchronous speeds, it would make little difference which ballast was used. It is interesting to note that one type of sequence-start series ballast has been used extensively for some time in a number of weaving and other textile operations without "strobe" difficulty.

In using sequence-start ballasts, if the No. 1 lamp fails, both lamps will go out. Rueter has

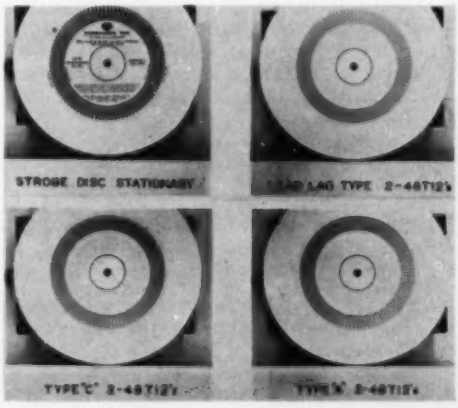


Figure 11. Effects of strobe on a series of photographs taken at F-22 with one-second exposure, using black and white film with an A.S.A. exposure of 50.

shown the effect of reduced current on Slimline hot cathode lamp life.[5] If the No. 2 lamp goes out the No. 1 lamp will operate at a reduced current which will shorten the life of the lamp if allowed to operate. If the lamps require a long time to strike due to low line voltage, more positive ion bombardment will occur which will remove active material from the cathode and may cause premature lamp failure.[6] Where a large number of starts are required per day, lamps on sequence-start circuits may sputter more and have premature failure. In recent tests, lamps have provided 4500 to 5000 hours with a 3-hour on 20-minute off cycle (7 starts per day).

One should note the difference in wiring of the lead-lag circuits and the types "A," "B," and "C." Connecting the sequence-start ballasts as a conventional lead-lag circuit will cause the lamps to operate at about 300 ma and in every case the writer has heard of, this has reduced the life of the lamp.

It is recommended, as in the case of the preheat type of lamp circuits where blinking occurred, that the lamps be replaced promptly and if operated abnormally for any length of time that lamp No. 1 be replaced along with lamp No. 2.

In lead-lag circuits there is abnormal ballast heating when one lamp fails. In sequence series circuits the ballast operates at open circuit or at partial current and hence there is a very low temperature rise. The objections of most of the sequence-start series type ballasts can be summed up as follows:

(1) The lamps operate in series, and are in phase with each other and do not have the slight stroboscopic correction found in the lead-lag circuits.

(2) Since the starting current is less than that of normal operating current, the positive ion bombardment may destroy some of the emissive coating from the cathodes and cause a reduction in lamp life.

(3) Since the lamps are operated in series, a failure of one lamp will cause the other lamp to go out. However, the failure of the second lamp will cause the first lamp to glow at relatively low current.

The advantages of most of the sequence-start series type ballasts can be summed up as follows:

(1) They will deliver more light output at the same power cost.

(2) Less watts loss in the ballast.

(3) Several types maintain relatively constant output with primary voltage variation of 100 to 130 volts.

(4) Reduction in weight, which in turn reduces fixture weight, cuts shipping costs and installation expense.

(5) There is usually less heat rise externally and internally —less B.T.U.'s to remove in air-conditioned installations. Some types have provided ventilated compartments for the capacitor which results in cooler operation.

(6) Fewer ballast failures.

(7) Mechanical designs are such as to provide a ballast having a low noise level.

(8) Temperature rise under abnormal operating conditions is low (i.e. when either lamp is out).

(9) Small size permits installation in standard Slimline channels and permits troffer type fixtures to pass Underwriter's requirements.

(10) Prices of ballasts are lower, thereby making it possible for an instant-start type of fluorescent lamp fixture to be competitively priced with the preheat types.

(11) Uses less critical material such as iron and copper.

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6. Steinberg, E. B.: "How to Extend Electron Tube Life," *Electrical Manufacturing*, (November 1950).

New I.E.S. Handbook Now Available at Special Price

Hundreds of orders are being received daily at I.E.S. headquarters for the new second edition I.E.S. Lighting Handbook. Copies of the new lighting authority are being reserved by members and non-members who are taking advantage of the special reduced pre-publication price and who will also be among the first to receive their copies when the book is published in October.

The new Handbook is in no way a "reprint" of the first edition (1947). Each section, covering every facet of lighting technique and application, has been restudied and rewritten to meet up-to-the-minute lighting practice by over 400 technical committee members. The second edition will comprise over 900 pages devoted entirely to the subject of lighting, answering 1001 everyday questions about lighting problems.

Members of the I.E.S. are entitled to one copy of the Handbook at the pre-publication price of $4.50 if reserved now. A special price of $5.50 has been extended to non-members, the same price applying on extra copies to members or in quantities.

I. E. S. Research for Defense

By A. F. WAKEFIELD

The Society now has four Task Committees, with the possibility of organizing three or four more. Present activities cover: Researches in connection with artificial moonlight; aiding to direct the policy of the manpower division with regard to scientific personnel; recommendations for civilian light control for protection and under attack; and plant protection for defense leading to adoption of the recommended practice as an American Standard.

THE NATION'S professional societies constitute one of the country's most valuable pools of specialized, applied knowledge available to the military in both the prosecution and the defense phases of war, and in the modern, so-called peacetime, interims. These talents can and should be utilized increasingly for our national safety. It is reasonable to assume that all professional societies are willing, in fact, would welcome action as an escape from the frustration which in time of war frequently overtakes the professional man who is unable to contribute front-line brawn or direct military experience.

The feeling within the Society is that defense is a year in, year out job. The hostile hazards are there all the time and, since some of the problems of defense take long to solve, we gain time if we plan through the years instead of in the face of an emergency. Many I.E.S. members would have liked to help steer a steadier course than the nation has followed between World War 1 and World War 2½.

That is why in 1948 our Society, whose objectives might seem to the undiscerning to be quite remote from defense importance, appointed a special committee to offer the voluntary services of the membership to military defense problems concerning illumination. The Special Task Committee appointed was selected for the competencies of members in whatever subjects might be assigned to them.

In the committee's first search for clues to the question of how to aid defense, a document of wide application was turned up: "Bibliography of Blackout and Dimout Practices During World War II, including an Engineering Digest of Defense Lighting." It had been prepared as recently as 1949 by the Special Committee on Wartime Lighting Practices. The Foreword to this thirty-page report and eleven pages of bibliography states in part: "The Committee selected the material in this record from civic, military, and private files in every section in the United States and from Great Britain and Germany."

It should be noted that during the late war several Sections and Chapters of I.E.S., as well as their officers and local committees were cited for their operation in various phases of the dimout and blackout.

In quite different vein, the record revealed a communication from the Commander of the Submarine Force, U. S. Atlantic Fleet, expressing appreciation for the work done by a special task committee in improving habitability of the snorkle-type submarine. The study included improvement of environmental conditions such as illumination, color, and effects having psychological bearing upon men who live under water for long periods.

In the present emergency, the following three steps were taken toward accomplishing the objectives of aid to defense which the Society had set for itself:

(1) It was recommended to the Society Council that an early National Conference of the Society be held in Washington in order that a part of the program could be devoted to defense subjects, readily available for the convenience of the planning echelon of the military. This Conference will meet in Washington, D. C. on August 27-30, 1951.

(2) It was agreed that an article regarding Lighting Applied to Defense would be helpful. As this is written, the material is being issued under the title "Lighting and the Nation's Welfare."

(3) It was suggested that the Chairman of the Coordinating Committee for Defense ask the President of the Society to offer these services to the Secretary of Defense and various defense agencies.

In the last case, all of the replies expressed high appreciation of the Society's intentions, and several included the name or names of individuals who

Author: Co-Chairman, Coordinating Committee for Defense, I.E.S.

might be grateful for counsel from I.E.S. committees. As a result, it was found that the Engineering and Development Laboratories at Ft. Belvoir had a basic and broad problem which was not covered by the then rather inadequate budget. The problem is indicated by the fact that in the first World War the battle of Jutland ceased because darkness fell. The Infantry problem of artificial moonlight and the confusion caused by the direction of shadows, even when we are speaking of only small parts of units of light, is actually a lighting problem. Under the chairmanship of Prof. L. M. N. Bach of Tulane University, a keen student of threshold values of illumination, a committee has been organized with a development contract directly from Ft. Belvoir.

All branches of the services learned to fight the clock around in the late war. The Navy's experience in Iron Bottom Bay was only the beginning of learning how to slug it out with the enemy after dark. The Air Force seems to have been born with the proclivity for 'round the clock fighting.

Recently, in order that the Defense Committee might have available the various talents of the members of the Society, a talent survey has just been completed as an instrument of the committee's work.

Through the Local Activities committee of the Society, it was recommended that joint meetings of the Chapters and Sections of I.E.S. with the Local Posts of the American Society of Military Engineers would acquaint the members of both societies with facts of mutual interest and benefit.

The regular I.E.S. Technical Committee on Plant Protection is now preparaing a report to be offered to the American Standards Association to become the standard of defense lighting for plant protection.

The Executive Committee of the Society has asked the Defense Committee to prepare a Recommended Practice of Civilian Light Control for protective purposes and when under attack. The Society feels that it is much better to have a well thought-out Practice in advance, rather than to criticize a last minute emergency Practice, or lack of Practice, afterward.

Three-Way Approach to Comfort for Industrial Area

Three factors contributing to increased comfort in working areas are good lighting, sound-proofing and air-conditioning. In the general shop area of the Woodward Governor Co., Rockford, Ill., 45-50 footcandles illumination is provided by 750 two-lamp industrial units recessed in the 14-foot high ceiling. The area, 160 x 224 feet in size, is air-conditioned, as are most of the other departments of the plant. The ceiling is of acoustic tile.

The broken rows of luminaires are on six-foot centers, three feet between each two units. Machinery is painted gray and walls are of yellow and green tile. (Photo courtesy of the Woodward Governor Co.)

The Functional Visual Activities in the Home

And the Location and Extent of the Associated Areas to be Illuminated

Prepared by the Committee on Residence Lighting of the Illuminating Engineering Society

Foreword

After the publication of "Lighting Performance Recommendations for Portable and Installed Residence Luminaires"* the need for studies which would further define most of the areas and stations for applied lighting became evident. This report is an extended revision of Appendix B of the former report.

The following material shows pictorially where a representative working plane or area is located at specific points in the home, information which will aid the equipment designer to determine the performance of his equipment, the lighting engineer to measure the performance of an installation, and the home owner to locate portable lamps for optimum lighting. The Committee wishes to thank Miss Kaye Leighton for the illustrations in this report.

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Introduction

A basic consideration in residential lighting is that of defining the areas to which the light for the various specific visual tasks must be delivered. Each of these areas may be described by its size and its location in the room. Its position may often be further described with respect to furniture or a furniture grouping, and finally, in relation to the position of the eyes of the user of the lighting. It is recognized that the actual surfaces to which the specified illumination is to be delivered may be flat, contoured and have varying depths. For the sake of simplicity and practicality, each area here is considered a plane. For brevity, they shall be called illumination test planes.*

Through the establishment of these test planes one may equitably determine how well a specified piece of lighting equipment is suited to illuminate any one or more of the seeing tasks found in the home. These test planes should also be helpful to designers of new equipment.

The lighting practitioner can design the more critical parts of the complete home installation with objective certainty with the establishment of these test planes. Finally, the homemaker can place her portable lighting equipment to the best advantage through the simple expedient of applying the rules of positioning that are a part of this method.

The positioning of these test planes is based upon the average heights of men and women when standing or when seated. The most representative dimensions of chairs, tables, desks, dressing tables, and dressers have also been taken into account. Other dimensions for the test plane and associated conditions than those recommended here could be employed. However, those set forth have the advantage of fulfilling a high percentage of realistic home situations and actual visual requirements.

The following activities are included in this group of recommended test planes and their respective locations:

Reading—seated position, upholstered and cushioned furniture—chairs and davenports
Reading and Writing—seated position at desks
Reading—seated position in bed
Reading piano music — seated at spinet piano
Sewing—seated position for
  (1) hand sewing
  (2) machine sewing
Facial make-up
  (1) seated position, dressing table
  (2) standing position, dresser
Shaving and facial make-up—standing position at bath mirror
Food preparation and kitchen duties —standing position at
  (1) work counter
  (2) sink
  (3) range
Laundry work — standing position at
  (1) laundry trays
  (2) ironing board
  (3) seated position at ironer
Home carpentry and painting—standing position at work bench

*Illuminating Engineering, Vol. XLI, No. 7, p. 521 (July 1946).
Approved by the Council of the Illuminating Engineering Society, October 1950.

*In addition to supplying specified illumination values for the various illumination test planes, it should be remembered that satisfactory lighting is also dependent upon distribution of light to all those areas that can be seen when viewing the test planes. Ratios of the brightness between the test plane and its surroundings of approximately three to one are desirable. Ratios over ten to one should be avoided.

Location and Extent of Visual Test Plane Areas

Figure 1. READING — Seated position, upholstered furniture — in chairs and ends of davenports.

Floor-based Lamps. The plane to be illuminated is 14 inches wide and 12 inches high. Its center is 26 inches above the floor and it is tilted up 45 degrees, toward the eyes of the reader. The vertical axis through the center of the lamp shade establishes the positioning of the source of light. This axis may be placed on either side of the reader. To locate this axis in relation to the illumination test plane measure from center of this plane straight out to one side 20 inches and then straight back a distance of 16 inches. The bottom edge of the shade should not be materially higher than the selected 40-inch eye-height, since the shade occupies a position close to the reader's head. Lamp table height at 25 inches is suggested. The distance from the eyes to the test plane will vary from approximately 14 to 20 inches, depending upon the posture assumed.

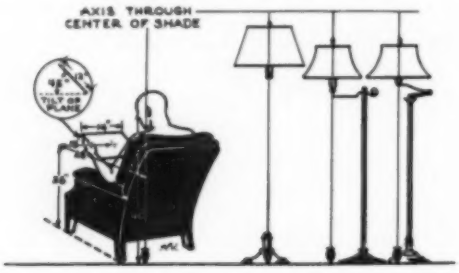


Figure 2. READING — Seated position, upholstered furniture — in chairs and ends of davenports.

Table-based Lamps. The plane to be illuminated is 14 inches wide and 12 inches high. Its center is 26 inches above the floor and it is tilted up 45 degrees, toward the eyes of the reader. The vertical axis through the center of the lamp shade establishes the positioning of the source of light. This axis is to the rear and to one side of the reader — it may be on either side. To locate this axis in relation to the illumination test plane measure from center of plane straight out to one side 15 inches and then straight back a distance of 26 inches. Since the lower edge of shades on floor lamps is usually substantially above the selected 40-inch eye-height, these lamps are placed to the rear of the reader to prevent the visual discomfort of viewing directly or indirectly the lower inside surfaces of the shade or other luminous areas intended to be hidden by the shade. The distance from the eyes to the test plane will vary from approximately 14 to 20 inches, depending upon the posture assumed.

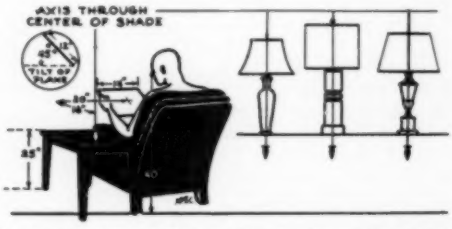


Figure 3. READING — Seated position, upholstered furniture — in chairs and ends of davenports.

Wall-hung Lamps. The plane to be illuminated is 14 inches wide and 12 inches high. Its center is 26 inches above the floor and it is tilted up 45 degrees, toward the eyes of the reader. The vertical axis through the center of the lamp shade establishes the positioning of the source of light. This axis is to the rear and to either one side or the other of the reader. To locate this axis in relation to the illumination test plane, measure from center of plane straight out to one side 15 inches and then straight back a distance of 26 inches. Refer to floor-based lamps in Fig. 1. The suggested position of the lower edge of the shade (48 inches) is well above the selected eye-height, its location must be to the rear of the reader. The distance from the eyes to the test plane will vary from approximately 14 to 20 inches, depending upon the posture assumed.

Location and Extent of Visual Test Plane Areas

Figure 4. READING, WRITING AND DRAWING — Seated position on unupholstered chairs having eighteen-inch seat height.

Table-based Lamps. The plane to be illuminated is 14 inches wide and 12 inches high. It lies in a horizontal plane on the desk top. Its center is 30 inches above the floor and 9 inches up from the front edge of the desk. The vertical axis through the center of the lamp shade establishes the position of the light source. This axis is to one side of the individual (to the left for the right-handed and to the right for the left-handed). To locate the axis of the light source measure straight out from the center of the test plane 15 inches and straight back from the front of desk edge 12 inches. The selected eye-height is 14 inches above the desk top or 44 inches above the floor. The bottom edge of the shield on the light source should not be higher than 15 inches above the desk top to prevent the visual discomfort of viewing any substantial part of the lower inside of the shade.

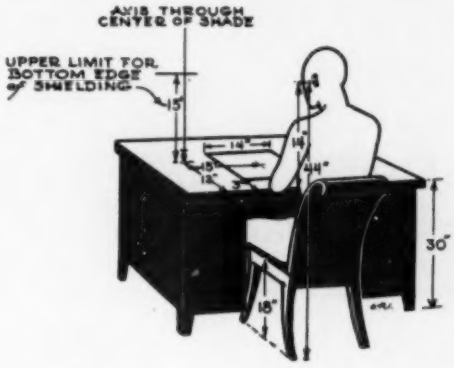
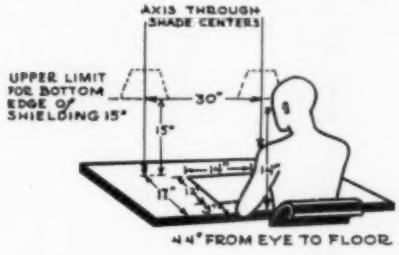


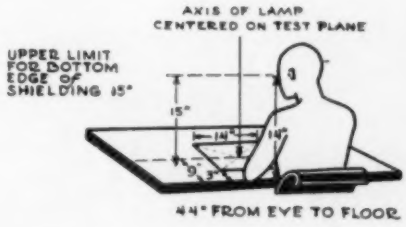
Figure 5. READING, WRITING AND DRAWING — Seated position on unupholstered chairs having eighteen-inch seat height. (Same as Fig. 4.)



Wall-based Lamps. The plane to be illuminated is 14 inches wide and 12 inches high. It lies in a horizontal plane on the desk top. Its center is 30 inches above the floor and 9 inches away from the front edge of the desk. The vertical axis through the center of each of the two lamp shades establishes the position of the light sources. These are placed 30 inches apart and 17 inches back from the front edge of the desk. The selected eye-height is 14 inches above the desk top or 44 inches above the floor. The bottom edges of the shades on the light sources should not be higher than 15 inches above the desk top. This is to prevent the visual discomfort of viewing any substantial part of the lower inside of the shades.

Figure 6. READING, WRITING AND DRAWING — Seated position on upholstered chairs having eighteen-inch seat height. (Same as Fig. 4.)

The plane to be illuminated is 14 inches wide and 12 inches high. It lies in a horizontal plane on the desk top. The center is 30 inches above the floor and 9 inches away from the front edge of the desk. The vertical axis of the light source is positioned directly over the center of the test plane. *Linear light sources* are intended in this positioning. The selected eye-height is 14 inches above the desk top or 44 inches above the floor. The bottom edge of the shield on the light source shall not be higher than 15 inches above the desk top.



This is to prevent the visual discomfort of viewing any substantial part of the lower inside of the shield.

Location and Extent of Visual Test Plane Areas

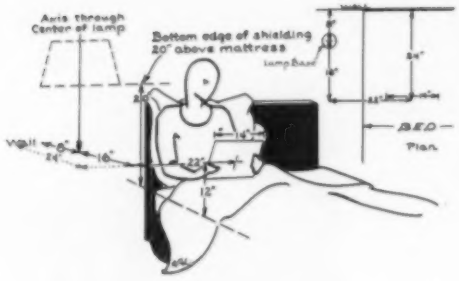
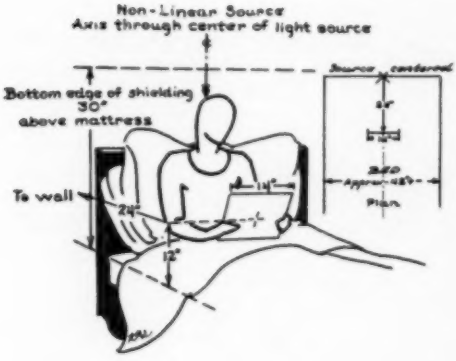


Figure 7. READING — Seated position in bed.

Table-based or Floor-based Lamps. The plane to be illuminated is 14 inches wide and 12 inches high. Its center is 12 inches above the top mattress line and it is tilted up 45 degrees, towards the eyes of the reader. The vertical axis through the center of the lamp shade establishes the positioning of the source of light. This axis is to the rear and to one side of the reader — it may be on either side. To locate this axis in relation to the illumination test plane, measure from center plane straight out to one side 22 inches and then straight back a distance of 16 inches. This also locates this axis 8 inches out from the wall. The center of the test plane is 24 inches out from the wall. The bottom edge of the shade should not be materially higher than the selected eye-height, which is 20 inches above the top mattress line, since the shade occupies a position close to the reader's head.

Figure 8. READING — Seated position in bed.

Wall-based Lamps — non linear light-source types. The plane to be illuminated is 14 inches wide and 12 inches high. Its center is 12 inches above the top mattress line and it is tilted up 45 degrees, towards the eyes of the reader. The vertical axis of the center of the light-source is centered back of the reader and the test plane. It is also placed next to the wall. The center of the test plane is 24 inches out from the wall. The bottom edge of the light-source shielding is 30 inches above the mattress.



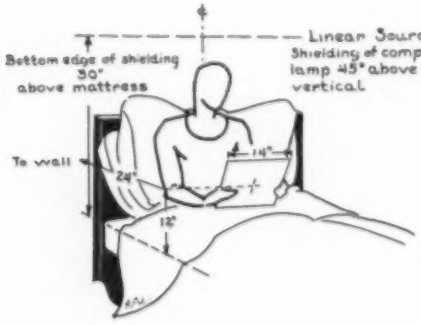
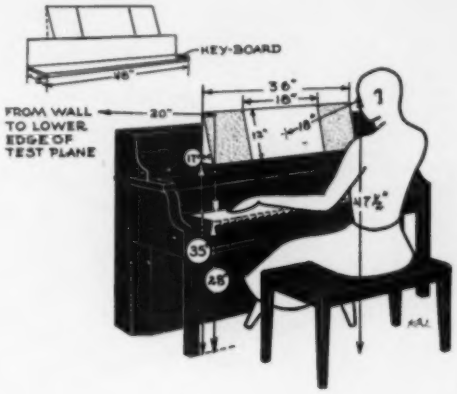


Figure 9. READING — Seated position in bed.

Wall-based Lamps — linear light-source. The plane to be illuminated is 14 inches wide and 12 inches high. Its center is 12 inches above the top mattress line and it is tilted up 45 degrees, towards the eyes of the reader. The center of the linear light source is back of the reader and in line with the center of the test plane. It is also placed next to the wall. The bottom edge of the light-source shield is 30 inches above the mattress, and complete shielding of this source is to be obtained at 45 degrees above the vertical.

Figure 10. READING PIANO MUSIC — Seated on unupholstered bench.

The plane to be illuminated (the music rack) is 18 inches wide and 12 inches high. Its bottom edge is 35 inches above the floor and is tilted back from the vertical. The bottom edge of the plane to be illuminated is 20 inches out from the wall. In addition to the primary plane to be illuminated, two secondary planes are also significant, those on each side of the principal music rack area shown dotted, and the top of the keyboard. The front back depth of the keys are to be taken at 8 inches and their width 48 inches. They are 28 inches above the floor. The distance of the eye to the center of the test plane is approximately 18 inches. The bottom edge of the light-source must protect the eyes at 47½ inches above the floor.



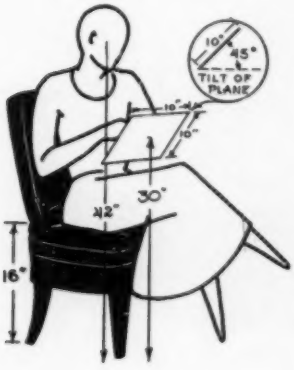


Figure 11. HAND SEWING — Seated position, upholstered chair without arms.

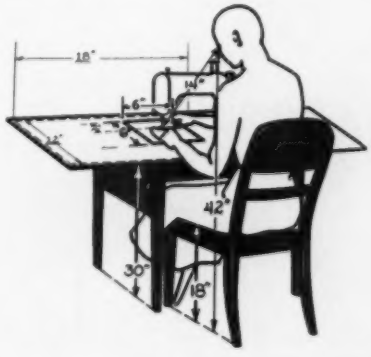
The plane to be illuminated is 10 inches wide and 10 inches high. Its center is 30 inches above the floor and it is tilted up 45 degrees toward the eyes of the sewer. Lamps placed beside the individual must be adequately shielded. The selected eye-height is 42 inches. The eyes are approximately 17 inches from the test plane center.

Figure 12. MACHINE SEWING — Seated position on unupholstered chair having eighteen-inch seat height.

The plane to be illuminated is 6 inches by 6 inches. Its center is 30 inches above the floor. The needle point is positioned on center 2 inches forward from the back edge.

In addition to the primary plane to be illuminated, a secondary plane is also of significance. This secondary plane measures 12 by 18 inches and is positioned so that the needle point is centered on the 12-inch dimension and 6 inches in from the right hand edge of the 18-inch dimension.

The selected eye-height is 42 inches. The eyes are approximately 14 inches from the needle point location on the test plane. The bottom edge of the light source shield must protect the eyes at 42 inches above the floor.



Location and Extent of Visual Test Plane Areas

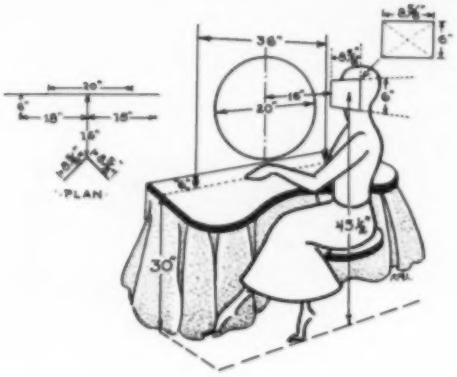


Figure 13. FACIAL MAKE-UP — Seated position, in front of a dressing table or a vanity dresser.

Table-based or Wall-hung Lamps. The planes to be illuminated have been selected to represent the two sides and the front of the face. They are at right angles to each other. They meet at a line directly in front of the face. This line of convergence or intersection is 16 inches out from the mirror. A 20-inch circular mirror is illustrated. Each plane is 8⅝ inches wide and 6 inches high. They are centered vertically at 45½ inches above the floor. The vertical axis through the centers of the two required light-sources are placed 36 inches apart and 6 inches out from the wall.

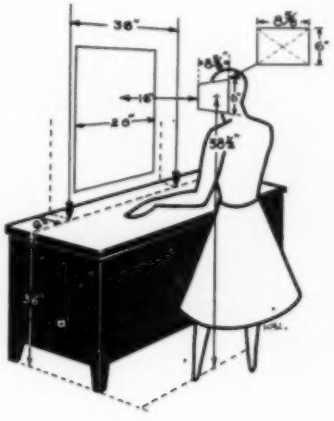


Figure 14. FACIAL MAKE-UP — Standing position, in front of a dresser.

Table-based or Wall-hung Lamps. The planes to be illuminated have been selected to represent the two sides and the front of the face. They are at right angles to each other. They meet at a line directly in front of the face. This line of convergence or intersection is 16 inches out from the mirror. A rectangular mirror 20 inches wide is illustrated. Each plane is 8⅝ inches wide and 6 inches high. They are centered vertically 58½ inches above the floor. The vertical axis through the centers of the two required light-sources are placed 36 inches apart and 6 inches out from the wall.

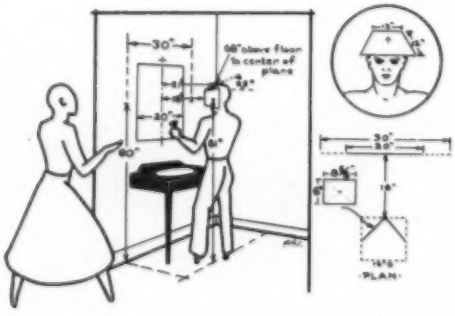


Figure 15. SHAVING AND FACIAL MAKE-UP — Standing position at bath mirror.

The planes to be illuminated have been selected to represent:

(a) The two sides and the front of the face.

(b) The top of the head.

The former (a) are at right angles to each other. They meet at a line directly in front of the face. This line of convergence or intersection is 16 inches out from the mirror. A rectangular mirror 20 inches wide is illustrated. Each plane is 8⅝ inches wide and 6 inches high. They are centered vertically 61 inches above the floor.

The plane (b) representing the top of the head is 12 inches square, its front edge is 16 inches from the mirror, it is tilted up 25 degrees above the horizontal and its center is 68 inches above the floor. The vertical axis through the centers of the light-sources on each side of the mirror are 30 inches apart.

Figure 16. FOOD PREPARATION AND KITCHEN DUTIES — Work counter surfaces — standing position.

The plane to be illuminated is 24 inches wide and 20 inches deep. It is located with its front edge along the work counter, and it is 36 inches above the floor. The lower shielding edge of wall mounted lighting units should not be higher than 58 inches above the floor.

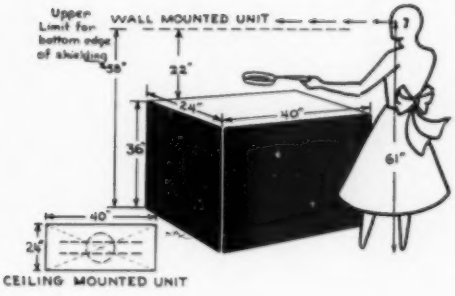
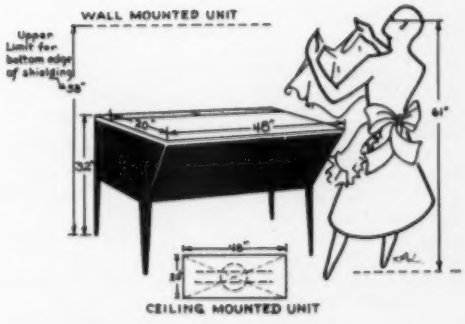


Figure 17. FOOD PREPARATION AND KITCHEN DUTIES — Range and sink tops — standing position.

The plane to be illuminated is 40 inches wide and 24 inches deep. It represents the entire area of the range or sink top. It is 36 inches above the floor. The lower shielding edge of wall mounted lighting units should not be higher than 58 inches above the floor. Ceiling mounted units are centered over the work surface as illustrated. The dashed circle indicates the positioning of incandescent lamps, while the parallel straight dashed lines position fluorescent tubes.

Figure 18. LAUNDRY WORK — Top and inner surfaces of laundry trays, standing position.

The selected plane to be illuminated is 48 inches wide and 20 inches deep and it is 32 inches above the floor. The lower shielding edge of wall mounted lighting units should not be higher than 58 inches above the floor. Ceiling mounted units are centered over the plane. The dashed circle shows the positioning of incandescent lamps, while the parallel straight dashed lines position fluorescent tubes.



Location and Extent of Visual Test Plane Areas

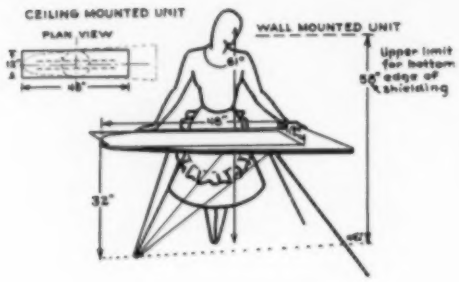
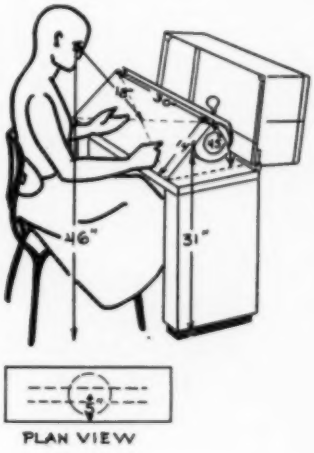


Figure 19. LAUNDRY WORK — Hand ironing, standing position.

The selected plane to be illuminated is 48 inches wide and 12 inches deep. It is 32 inches above the floor. The lower shielding edge of wall mounted lighting units should not be higher than 58 inches above the floor. Ceiling mounted units are centered over the work surface as illustrated. The dashed circle indicates the positioning of the incandescent lamps, while the parallel straight dashed lines position fluorescent tubes.

Figure 20. LAUNDRY WORK — Machine Ironing — seated position at ironer.

The selected plane to be illuminated is 30 inches wide and 14 inches deep. Its center is 31 inches above the floor and it is tilted up 45 degrees, towards the eyes of the individual. Wall mounted lighting units shall have their lower shielding edge not higher than 48 inches above the floor. Ceiling mounted units are centered 5 inches back from the front edge of the illuminated plane. The dashed circle indicates the positioning of the incandescent lamps, while the parallel straight dashed lines position fluorescent tubes.



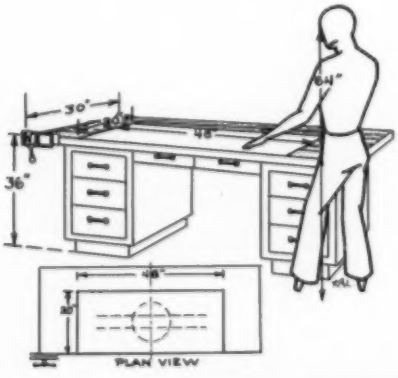


Figure 21. HOME CARPENTRY AND PAINTING — Standing at work bench.

The selected plane to be illuminated is 48 inches wide and 20 inches deep. Its front edge is even with the front of the bench. It is 36 inches above the floor. Ceiling mounted lighting units are centered over the work surface as illustrated. The dashed circle indicates the positioning of the incandescent lamps, while the parallel straight dashed lines position fluorescent tubes.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Summary of Action Taken At June Council Meeting, New York

The last Council meeting of this year's Administration met at the Lexington Hotel, New York City, on June 14. Present were: Walter Sturrock, President, presiding; E. M .Strong and R. L. Zahour (proxy for S. G. Hibben), Vice-Presidents; A. H. Manwaring, General Secretary; R. F. Hartenstein, Treasurer; D. M. Jones, N. D. McDonald (proxy for L. A. Hobbs), Roy A. Palmer and M. N. Waterman (proxy for Myrtle Fahsbender), Directors; J. B. Browder, R. W. Corwin (proxy for C. O. Martin), G. F. Dean, L. H. Graves (proxy for F. A. Covington), C. N. Laupp, J. S. Schuchert, R. G. Slauer and F. C. Winkler, Regional Vice-Presidents; and A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor of ILLUMINATING ENGINEERING; and C. E. Ellis, Advertising and Promotion Manager. Guests included: E. W. Beggs, G. W. Clark, P. H. Hildebrand, F. P. Labey, and C. H. Rex.

First order of business, following the call for proxies, was the approval of the Minutes of the May 9 meeting of the Executive Council Committee, with specific attention of Council for approval of the reports of the Board of Fellows, and the Nomenclature Committee, and the subletting of space at Headquarters to the Central Bureau of I.C.I.

OFFICERS ELECTED

The report of the Tellers, on Society elections, was presented by A. D. Hinckley, Executive Secretary. Details of the national and section elections are given elsewhere in Telecast, this issue.

The report further noted that the required two-thirds vote was received on the Constitutional change up for ballot, changing the Society's dues fee.

In connection with the election returns, G. F. Dean, Canadian Regional V-P, reported that Douglas Borden, who was elected Vice-President for this Region, could not now fill the office, due to a change in business. He recommended that Frank Labey, Mr. Borden's business successor, be appointed to this office. Council approved the appointment.

MEMBERSHIP STATISTICS

Ten new Members, the reinstatement of one, and the transfer to full Member of 9 Associates, were recommended for election by the Board of Examiners. In addition, the Board reported the election and/or reinstatement of 101 Associate Members and 18 Student Members. Favorable action on this report, together with other changes in membership results in current statistics as follows:

September 30, 1950		June 14, 1951
7057	Total Membership	7479
32	Members Emeritus	32*
41	Fellows	42
1610	Members	1721
5005	Associate Members	5395
309	Student Members	289

*Includes 10 Fellows of the Society.

LOCAL ACTIVITIES

In reporting on current activities throughout the Society's Sections and Chapters, E. M. Strong, Chairman of this committee, called on Mr. Sturrock for his impressions following his recent nation-wide travels to many I.E.S. Regions. Mr. Sturrock told Council of the several highly successful Regional and Section meetings he had attended, reporting favorably on a number of worthwhile local programs.

Mr. Strong asked Regional Vice-Presidents present at Council to speak on their own Regions' activities. Mr. Winkler outlined procedures followed for the recent Great Lakes Conference, stressing the need to stimulate large attendance at these highly important meetings. He also spoke in detail of the regional contests for "My Most Interesting Installation" and how very beneficial such programs may be. He mentioned that this feature could be promoted on a national basis.

Mr. Laupp reported on the Midwest Regional Conference in Davenport, Iowa, also mentioning the need for early planning to stimulate attendance.

Mr. Browder, in describing the Southern Regional meeting felt that on a percentage basis (as compared with the percentage of membership attending National conferences) most Regional Conferences attracted very good attendance. He advised that registration fees be kept as low as possible.

Mr. Slauer, Regional Vice-President for Northeastern Region, noted that this meeting was held in the Fall of the year and attracted an attendance "lower than hoped for, but better than budget."

G. F. Dean, Canadian Regional V-P, noted several practices which added to the success of their Conference in Quebec, namely active cooperation and meetings with Local Representatives prior to the Conference; presentation of past-chairmen awards.

Mr. Strong felt that the suggestion of well-planned Local Representative cooperation should be encouraged in all Regions.

CENTRAL NEW YORK SECTION

F. C. Winkler, Regional V-P for Great Lakes, presented for approval a petition from Central New York Chapter (Syracuse) for Section status. Upon presentation of qualifications meeting such transfer, Council took action to establish this group as a Section of I.E.S.

Council took favorable action also on the request of the St. Louis and Chicago Sections to change their boundaries, to be based on county lines as recommended.

Completing the report on Local Activities, Mr. Strong mentioned the Local Activities Committee meeting held in New York June 13, attended by Regional Vice-Presidents. He noted the committee's aim is to provide a training program for new V-Ps. Two guides are being offered for Regional V-P operation and Regional Conference procedure, as revised this year.

PUBLIC CONVEYANCES

E. W. Beggs, Chairman of the Committee on Interior Lighting for Public Conveyances, submitted this committee's Study Report on the lighting of trains and buses. The report was approved by Council for reference to the Publications Committee.

Canadian Regional Conference Held in Quebec

A full and interesting program of both technical sessions and entertainment, prepared by the Quebec Chapter as host, assured the success of the Canadian Regional Conference, at the Chateau Frontenac, Quebec, May 10 and 11.

Four technical sessions were attended by 150 delegates and two luncheons were held jointly with local societies of architects and contractors.

A habitant-style barn dance was the closing event in the entertainment for delegates and guests, which included a bus excursion to Montmorency Falls, the shrine of Ste. Anne de Beaupre and the Lake Beauport sports center; a reception by the government of the province of Quebec at which the Honorable Paul Beaulieu, Minister of Trade and Commerce of the Province, was the special guest.

The opening of the Conference was an address of welcome by Frank Dean, Regional Vice-President of the Canadian Region. President Walter Sturrock then spoke on "I.E.S. Activities," stressing the importance of artificial light for all phases of the defense program — for the armed forces, for the production front, for civil defense.

TECHNICAL SESSIONS

Thursday, May 10

Morning

Chairman: Henry Lushington, Chairman, Maritime Chapter.

"New Light Sources"—Speaker, Sam Hibben, Westinghouse Electric Corp. Bloomfield, N. J. Debater, Jos. Bateman, Canadian General Electric Co., Ltd., Toronto.

"Illuminating Measurements" —Speaker, Prof. E. M. Strong, Cornell University, Ithaca, N. Y. Debater, Walter Sturrock, General Electric Co., Cleveland.

Joint Luncheon with "La Societe des Architectes de Quebec." Chairman: Frank Labey, Chairman, Montreal Section.

Address of Welcome: Major Lucien Borne.

"Lighting and Architecture"—Ward Harrison, Past-President, I.E.S.

Afternoon

Chairman: John T. Hornsby, Chairman, Ottawa Chapter.

"Hospital Lighting"—Speaker, James Govan, Architect, Toronto. Debater, Eward Haacke, J. A. Wilson Lighting and Display Ltd., Montreal.

"Church Lighting" — Speaker, Edward Rambusch, Rambusch Decorating Co., New York. Debater, Howard Wright, Curtis Lighting of Canada Ltd., Toronto.

"Interior Lighting for Commercial Establishments"—Speaker, C. H. Goddard, Sylvania Electric Products Inc., New York. Debater, D. W. Patterson, Amalgamated Elec. Corp., Montreal.

"Tools for the Colourist" — Speaker, W. Ed Carswell, Sherwin-Williams Co. of Canada, Ltd., Toronto. Debater, F. G. Reed, Hydro-Electric Power Commission of Ontario, Toronto.

Friday, May 11

Morning

Chairman: J. W. Greenlaw, Chairman, Winnipeg Chapter.

"Indoor Sports Lighting" — Speaker, Prof. Gilles Sarault, Laval University and Chairman, Quebec Chapter. Debater, G. F. Mudgett, Canadian Westinghouse Co., Ltd., Hamilton.

"Protective Lighting"—Speaker, J. W. Lee, Philadelphia Electrical & Mfg. Co., Philadelphia. Debater, Vic Knudsen, Crouse-Hinds Co. of Canada, Ltd., Toronto.

"Street & Highway Lighting"—Speaker J. A. I. Kidd, Canadian General Electric Co., Toronto. Debater, Roy Eshelby, Northern Electric Co., Ltd., Ltd., Montreal.

Joint Luncheon with L'Association des Constructeurs de Quebec—Chairman, R. D. Allison, Chairman, Toronto Section.

"Lighting Problems Seen by the Contractor"—C. Howard Simpkin, Contractor, Montreal.

Afternoon

Chairman: G. F. Mudgett, Chairman, Hamilton Chapter.

"Defence Co-ordination"—Speaker, Major G. D. Mills, Canadian Army, Ottawa. Debater, Jos. Thomas, Canadian Laco Lamps, Montreal.

"Heat in Fluorescent Fixtures"—Speaker, E. H. Salter, Electrical Testing Laboratories, New York. Debater, Gilles Sarault, Tasse, Sarault & Associes, Quebec.

"Lighting Glassware Application" — Speaker, Dr. W. W. Shaver, Corning Glass Works, Corning, N. Y. Debater, Frank T. Groome, Holophane Co., Ltd., Toronto.

"Residential Lighting"—Speaker, Miss Margaret Lidstone, Canadian General Electric Co., Toronto. Debater, Miss Irene Auger, Interior Decorator, Quebec.

Credit for this successful conference goes chiefly to:

G. F. Dean, Canadian Regional Vice-President
George A. Watters, Conference Chairman
H. R. Payson, Vice-Chairman & Treasurer
W. Pednault, Secretary
Papers and Program Committee, Alex. de Lery, Chairman
Entertainment Committee, H. R. Payson, Chairman
Finance Committee, H. R. Payson, Chairman
Hotel Committee, Paul Beland, Chairman
Ladies Committee, Mrs. Gilles Sarault, Chairman
Publicity Committee, Bernard Marcoux, Chairman
Reception Committee, Romeo Martineau, Chairman
Registration Committee, Henri Fontaine, Chairman
Transportation Committee, Oscar Dorval, Chairman

(Left) Colorful "habitant-style" clothes are worn by G. Frank Dean, Vice-President of the Canadian Region and George A. Watters, Conference Chairman. In more formal attire are Mr. and Mrs. Sturrock.

(Lower left) President-Elect Sam Hibben looks well satisfied with his position between Mrs. George A. Watters and Mrs. G. F. Dean.

(Below) At the reception, Edward Rambusch, left, and Edwin E. Morris chat with Mrs. and Mr. W. J. Montabone.

Cleveland Section is Joint Sponsor Of Allied Arts Competition

The jointly-sponsored meeting of the Cleveland Section, I.E.S., and the Cleveland chapters of the American Institute of Architects and the Society of Industrial Designers, held April 26, brought to a close the year's work of the Section's Committee on Allied Arts. The purpose of the collaboration was to promote the integration of illumination, architectural and display methods.

The dinner-meeting was attended by 100 members, students and guests. Speaker of the evening was Prof. Stanley R. McCandless, who gave an illustrated talk on "Lighting for Designers."

Twenty teams of students from Western Reserve University School of Architecture, Case Institute of Technology and the Cleveland Institute of Art competed. A team consisted of one student architect, one engineer and one designer. Prizes were $100 (first), $50 (second) and $25 (third). These and the certificates for honorable mention, were presented by Mr. George Gund, president of the Cleveland Institute of Art.

The student teams had five weeks to prepare their solutions to a design problem which included:

(a) One ¼" rendering of the floor plan showing the design for general exhibition purposes and three floor plans, drawn to ¼" scale, showing the design of an auditorium as used for receptions, lectures and visual education purposes.

(b) One transverse section and one longitudinal section, drawn to ¼" scale, showing the treatment of the walls.

(c) The lighting systems for each of the various functions presented by overlay or other suitable means and a schedule to show footcandle levels, as distributed in the various areas.

(d) Wiring diagrams showing circuits as related to the various functions and wattage requirements.

(e) Lighting fixture details drawn to a suitable scale.

Winners of the competition are:

First prize: Raymond Febo, Western Reserve University; Rollin Waite, Case Institute; and Gerald Garfield, Cleveland Institute of Art.

Second prize: Jack Huddle, Richard Mott and Anthony Walley.

Third prize: Hugh B. VerBryck, George Edward MacDonald and Donald Hronek.

The jury included A.I.A. members Franklin Scott and J. Byers Hays, I.E.S. members Harry Ingraham and Ray Berger, and S.I.D. member Viktor Schreckengost. The Cleveland Section Allied Arts Committee consists of R. T. Dorsey, W. D. Riddle, Dana Rowten, R. Smart and K. A. Staley.

LIGHTING CALENDAR

Society Events

August 27-30, 1951 — Illuminating Engineering Society, National Technical Conference, Hotel Shoreham, Washington, D. C.

October 11, 1951—Meeting of I.E.S. National Council, New York, N. Y.

November 8, 1951—Meeting of I.E.S. Council Executive Committee.

December 13, 1951—Meeting of I.E.S. National Council, New York, N. Y.

January 10, 1952—Meeting of I.E.S. Council Executive Committee.

February 14, 1952—Meeting of I.E.S. National Council, New York, N. Y.

March 13, 1952—Meeting of I.E.S. Council Executive Committee.

March 13-14, 1952—South Pacific Coast Regional Conference, San Francisco, Calif.

March 20-21, 1952 — Pacific Northwest Regional Conference, Vancouver, B. C.

March 31, 1952—Meeting of I.E.S. National Council, Chicago, Ill. (Tentative)

April 6-8, 1952—Southwestern Regional Conference, Tulsa, Okla.

April 30-32, 1952—Southern Regional Conference, Nashville, Tenn.

April 30 - May 2, 1952—Canadian Regional Conference, Hamilton, Ontario.

May 5-6, 1952—Great Lakes Regional Conference, Cleveland, Ohio.

May 8, 1952—Meeting of I.E.S. Council Executive Committee.

May 22-23, 1952—East Central Regional Conference, Pittsburgh or Baltimore (Tentative).

June 12, 1952—Meeting of I.E.S. Council, New York, N. Y.

June 19-20, 1952 — Northeastern Regional Conference, Swampscott, Mass. (Tentative).

July 10, 1952 — Meeting of I.E.S. Council Executive Committee.

September 9-13, 1952 — Illuminating Engineering Society, National Technical Conference, Edgewater Beach Hotel, Chicago, Ill.

Industry Events

August 20-23, 1951 — Pacific General Meeting, American Institute of Electrical Engineers, Multnomah Hotel, Portland, Ore.

September 11-20, 1951 — Building Research Congress, London, England

September 17-20, 1951 — International Municipal Signal Association, 56th Annual Meeting, Mark Hopkins Hotel, San Francisco, Calif.

September 24-27, 1951—32nd Annual Meeting, Institute of Traffic Engineers, Ambassador Hotel, Los Angeles, Calif.

September 25-28, 1951 — Fall Meeting, The American Society of Mechanical Engineers, Minneapolis, Minn.

September 26-28, 1951 — Annual Meeting, Canadian Electrical Manufacturers Ass'n, General Brock Hotel, Niagara Falls, Ont.

October 1-3, 1951—Eastern Section, International Association of Electrical Inspectors, Chalfonte-Haddon Hall, Atlantic City, N. J.

October 4-6, 1951—American Physical Society, Gaseous Electronics Fourth Conference, General Electric Research Laboratory, Schenectady, N. Y.

October 8-12, 1951 — 39th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

October 9-10, 1951—National Farm Electrification Conference, Hotel Gibson, Cincinnati, Ohio

October 9-12, 1951 — National Electrical Contractors Associations, Annual Convention, Shoreham Hotel, Washington, D. C.

October 10-13, 1951 — The Electrochemical Society, Inc., Semi-Annual Convention, Statler Hotel, Detroit, Mich.

October 10-13, 1951 — International Association of Electrical Leagues, Annual Conference, Roosevelt Hotel, New Orleans, La.

October 15-17, 1951 — International Association of Electrical Inspectors, Southern Section, 23rd Annual Meeting, Hotel John Marshall, Richmond, Va.

October 15-19, 1951 — Fall 1951 Convention of the Society of Motion Picture and Television Engineers, Hollywood-Roosevelt Hotel, Hollywood, Calif.

October 22-24, 1951—33rd Annual Meeting, American Standards Ass'n, Waldorf-Astoria Hotel, New York, N. Y.

October 22-24, 1951 — National Electronics Conference, Annual Conference, Edgewater Beach Hotel, Chicago, Ill.

October 22-26, 1951 — American Institute of Electrical Engineers, Fall General Meeting, Hotel Cleveland, Cleveland, Ohio

November 12-15, 1951 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

November 25-30, 1951 — Annual Meeting, The American Society of Mechanical Engineers, Atlantic City, N. J.

December 2-5, 1951 — American Society of Refrigerating Engineers, 47th Annual Meeting, Hotel Roosevelt, New York, N. Y.

December 5-7, 1951 — Annual Meeting, National Association of Manufacturers, Waldorf-Astoria Hotel, New York, N. Y.

January 6-12, 1952 — The 4th Pan American Congress of Ophthalmology, Del Prado Hotel, Mexico City

January 21-25, 1952—Winter General Meeting, American Institute of Electrical Engineers, Hotel Statler, New York, N. Y.

March 10-13, 1952 — National Electrical Manufacturers Ass'n, Edgewater Beach Hotel, Chicago, Ill.

April 1-3, 1952 — Edison Electric Institute, Sales Conference, Chicago, Ill.

May 6-9, 1952 — Fourth International Lighting Exposition & Conference, Cleveland Municipal Auditorium, Cleveland, Ohio

June 23-27, 1952 — Summer General Meeting, American Institute of Electrical Engineers, Hotel Nicollet, Minneapolis, Minn.

August 19-22, 1952 — Pacific General Meeting, American Institute of Electrical Engineers, Phoenix, Arizona

VIEW of the attendance at the Midwestern Regional Conference, held in Davenport, Iowa.

Industrial Lighting Is Theme Of Midwestern Regional Conference

In view of the current defense and mobilization program, the theme for the 1951 Midwestern Regional Conference was "Industrial Lighting." A grand total of nearly 200 members and guests attended the technical sessions and banquet, held at the Hotel Blackhawk, Davenport, Iowa, May 18-19, with the Iowa Section as host.

The program opened with a welcome by Dean Barnhizer, Iowa Section, and C. P. Conrad, of the Iowa-Illinois Gas and Electric Co.

Charles N. Laupp, Vice-President of the Midwestern Region and chairman of the Milwaukee Chapter, was chairman of the morning session. Walter Sturrock, National President, was the first speaker, with the subject, "Where Do We Serve Today." He discussed the part that the Society and its members can and should play in the present national mobilization and defense program and outlined the various fields of lighting which must be kept alive during the emergency period.

A highlight of the conference was the Hospitality Hour and banquet Friday evening in the Rose Room and the Gold Room, when President Walter Sturrock was presented with a set of monogrammed cuff links and tie clasp. Guests for the evening were members of the Electrical Institute of the Tri-Cities. Speaker of the evening was Berlon C. Cooper, recently named consultant for the National Production Authority, who reviewed the present status of federal controls of materials, manpower, construction and prices. He expressed the opinion that despite a shortage of lighting materials, the lighting industry will be developed along with industrial expansion as a part of the national defense and mobilization program.

AMONG THE MANY attending the Midwestern Regional Conference are Walter Sturrock, I.E.S. President; George H. Edwards, President, Electrical Institute of the Tri-Cities; Berlon C. Cooper, Eastern Editor, *Electrical Construction and Maintenance;* and Charles N. Laupp, Vice-President, Midwestern Region.

Technical Sessions

Friday, May 18

Morning

Meeting Called to Order, W. Dean Barnhizer, Chairman.
Address of Welcome—C. P. Conrad, President, Iowa-Illinois Gas and Electric Co.
Introduction of Charles N. Laupp, Session Chairman.
"Where Do We Serve Today"—Walter Sturrock, I.E.S. President.
Discussion.
"Industrial Production Improves with Proper Lighting" — William H. Kahler, Westinghouse Electric Corp.
Discussion.
Conference Luncheon, W. Dean Barnhizer, presiding.
Introduction Speaker, Fenn C. Horton.
Address—"The Idea"—Dr. John J. Martin, D.O.S., Davenport, Iowa.

Afternoon

C. B. Pederson, Chairman.
"Evaluation of Lighting Techniques for Offices and Drafting Rooms," Robert L. Oetting, General Electric Co.
Discussion.
"Color Conditioning," accompanied by new film "A Case of Color," L. S. Oyster, E. I. du Pont de Nemours & Co.
Discussion.
"Localized Lighting and Inspection Problems," Robert J. Diefenthaler, General Electric Company.
Discussion.
Hospitality Hour.
Banquet—Charles N. Laupp, presiding.
"The Electrical Industry's Place in Lighting for Production and Mobilization . . . New Frontiers in Lighting"—Berlon C. Cooper, Eastern Editor, *Electrical Construction and Maintenance.*

Saturday, May 19

A. B. Hallaway, Chairman.
"Specialized Lighting Maintenance Service"—Melvin H. Galbraith, Approved Lighting Service, Cedar Rapids, Iowa.
Discussion.
"Sequence-Start Series Ballasts for Instant-Start Fluorescent Lamps"—H. U. Hjermstad, Sola Electric Co.
Discussion.
"Plant Protection with Adequate Lighting"—Edward H. Grieb, Holophane Co., Inc.
Discussion.
Closing Remarks by Charles N. Laupp, Vice-President, Midwestern Region.

Consensus of opinion of those present is that the 1951 conference had one of the most interesting programs and largest attendance of any held by the Midwestern Region. Those responsible for its success are:

Regional Conference Committee

J. C. Young, Jr., Chairman, W. Dean Barnhizer, G. E. Crider, R. H. Haase, F. C. Horton, H. P. Wilson.

Chapter and Section Chairmen

Chicago Section ..... C. B. Pederson
Cornhusker Chapter ..... Ed T. Taber
Heart of America Chapter ..... John M. Weir
Indiana Chapter ..... Cecil Hadley
Iowa Section ..... W. Dean Barnhiser
Milwaukee Section ..... Charles N. Laupp
St. Louis Section ..... William H. Simms
Twin City Section ..... A. B. Hallaway

The Honorary Reception Committee and Local Arrangements Committee were under the Chairmanship of F. C. Horton.

Great Lakes Regional Conference Presents Its Biggest Program

One of the Society's "biggest" Regional Conferences, certainly the biggest in terms of the technical program, was the Great Lakes Regional meeting held at the Hotel Gibson, Cincinnati, Ohio, May 24 and 25. The meeting was of Convention proportions in its other aspects also, with numerous committee meetings scheduled at breakfast, luncheon and in the evenings.

The Program and Papers Committee, under Ralph R. Enghouser of the Ohio Valley Section, arranged 38 separate events for the calendar of the two-day meeting, including 21 outstanding technical papers, luncheon addresses and entertainment. A separate session for visiting ladies was also planned, conducted under the chairmanship of Mary W. Held and Mary E. Dodds.

Interesting Job Contest

Aside from the technical program, the highlight of the Conference was the presentation of the finalists for top awards for "My Most Interesting Lighting Installation." The six contestants presented at the Great Lakes Conference were winners of contests held during the year in each of the Sections and Chapters comprising the Region. Competition on the local level was exceptionally keen, so that the winning installations making the grade to Cincinnati represented excellent installations of particular interest to delegates. Winners of the finals contest in Cincinnati were:

First—Floyd Sells, Detroit Edison Co. (winner of Michigan Section contest) for his installation of lighting a fur farm.

Second—Aileen M. Page, General Electric Co. (Cleveland Section winner) for relighting a living room.

Third — Vincent Mitchell, Rochester Gas & Electric Co. (Rochester Chapter winner) for the relighting of the First Federal Savings Building.

Runners-up were: Don Varner, Northwestern Ohio Chapter; Robert H. Goodman, Central New York Chapter; Ralph W. McClure, Ohio Valley Section.

Judges for the contest were Miss Mary Dodds, Walter Sturrock, Lee E. Tayler, A. F. Wakefield and S. G. Hibben.

The entire program centering around the contests for the most interesting job installed, was considered a most worthwhile project, both for the Conference program and as an activity within each of the Sections and Chapters. Many of the installations, winners and runners-up, will be published as application articles, with by-line, in Illuminating Engineering.

Technical Program

The Conference was opened May 24 with an Address of Welcome to the 159 registered delegates, by Honorable Albert Cash, Mayor of Cincinnati. Fred C. Winkler, Great Lakes Regional V-P, and Walter Sturrock, National I.E.S. President, also addressed the opening session, reviewing the regional and national aims of the Society.

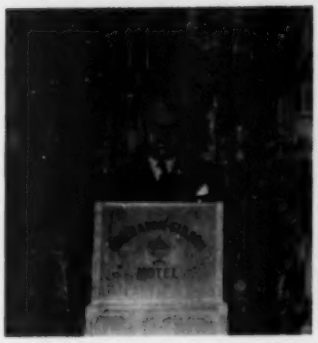
The fine technical program included:

"Nothing Is Too Much Trouble," by Edward W. Hodgetts, Cincinnati Gas & Electric Co. The story of the house that light built, a unique way of promoting lighting.

"Home Lighting Patterns for Today's Living Needs," by Mary E. Webber, General Electric Co., Nela Park, Cleveland, Ohio.

"Evaluation of High Bay Lighting Sources, Equipment and Systems," by J. W. Steiner, Westinghouse Electric Corp., Cleveland, Ohio.

"The Application and Economics of Low Bay Lighting Techniques." by Hoyt P. Steele, Benjamin Electric Mfg. Co., Des Plaines, Illinois.



Hon. A. D. Cash, Mayor of Cincinnati, welcomes the delegates to Great Lakes Regional Conference.

"Electro Luminescence," by Richard G. Slauer, Sylvania Electric Products, Inc., Salem, Mass.

"Lighting Hazardous Areas," by H. M. Baxter, Crouse-Hinds Co., Syracuse, N. Y.

"New Approach to Specialized Lighting Problems," by W. H. Kahler, Westinghouse Electric Corp., Cleveland, Ohio.

"Protective Lighting for Industry," by Merle E. Keck, Westinghouse Electric Corp., Cleveland, Ohio.

"Progress Report of the Committee on the Revision of the American Recommended Practice of Industrial Lighting," by E. A. Linsday, General Electric Co., Cleveland, Ohio.

"Progress Report," by Alston Rogers, General Electric Co., Cleveland, Ohio.

"Lamp and Lighting Progress — A Miracle of Confusion!" by Lester Twichell, Rochester Gas & Electric Corp.

"A Necessary Luxury," by Philip Adams, director of Cincinnati Art Museum. Luncheon address.

"Daylight Engineering for Schools," by Prof. R. L. Biesele, Jr., Southern Methodist University, Dallas, Texas. This paper presented through the courtesy of Libby-Owens-Ford Glass Co.

"Daylight in Classrooms," by Dr. R. A. Boyd, Director of Research, University of Michigan, Ann Arbor, Mich. This paper presented through the courtesy of American Structural Products Co.

"School Lighting," by Wilfred F. Clapp, Assistant Superintendent, School Organization and Plant, Department of Public Instruction, Lansing, Mich.

AT THE Great Lakes Regional Conference, C. W. McFee, General Chairman, makes last minute check at Registration Desk with Ed McGinnis and Dorothy Tedtman.

JUDGES of the contest for "My Most Interesting Lighting Job" conducted by the Great Lakes Regional Conference May 24-25 in Cincinnati. Left to right, S. G. Hibben, Al Wakefield, Lee Tayler. Walter Sturrock and Mary Dodds.

"Optometry and Illumination," by Dr. Glenn A. Fry, School of Optometry, Ohio State University, Columbus, Ohio.

"The Footcandle Problem," by Prof. E. M. Strong, Cornell University, Ithaca, N. Y. A progress report on visibility.

"Children's Reaction to Modern Classroom Lighting," by Dr. D. B. Harmon. This paper presented through the courtesy of the F. W. Wakefield Brass Co.

Awards for "My Most Interesting Lighting Installation."

"Progress Report for Study Lighting," by Mary E. Webber, Chairman, I.E.S. Residence Lighting Committee.

"Operation M," by Stella Fetzer, Director, Home Lighting Division, Cincinnati Gas and Electric Co.

Entertainment

In line with its other "Convention" type features, the Great Lakes Regional Conference also included an especially well-planned entertainment program. Two formal luncheons were a part of the program, as well as evening entertainments, and a tea following the closing session, given by the Cincinnati Gas and Electric Co. Highlight of the entertainment program was, however, the Presidential Reception and Banquet, honoring Mr. and Mrs. Walter Sturrock. Guests were taken by bus to the famous Lookout House at Covington, Kentucky for an evening of fun with NO SPEECHES. President and Mrs. Sturrock, and Mr. Winkler were the recipients of gifts from Sections and Chapters of the Great Lakes Region.

Planning

To plan a program of such proportions takes, it was agreed, thorough planning well in advance. The Great Lakes regional program got off to a good start back in November of 1950, when the first meeting was held in Cincinnati and preliminary details worked out and committees appointed. From the first of January onward, many meeting were held, and a great deal of work was done by many people. For some good ideas:

On the mornings of both meeting days, May 24 and 25, the chairmen for those days were invited to breakfast meetings, as were all the speakers on the program. At these meetings, timing, props, discussion, and any other feature affecting the smoothness of the day's operation was thoroughly discussed.

Co-chairmen were appointed to aid each of the session chairmen in the operation of all of the technical sessions. In that way there was not a hitch in the two-day program, and neither did any of the speakers run over their allotted time. A clock in clear view of the speakers and a warning lamp showing yellow two minutes before their specified time expired, kept speakers to schedule.

Committee Chairmen participating in the successful meeting were:

General Chairman—Charles W. McFee
Co-Chairman—R. J. Breitenstein
Executive Committee—Mr. McFee, E. B. Bentley and Robert W. Brown
Finance—Edward B. Bentley
Hotel and Entertainment—E. J. McGinnis
Ladies Committee—Mary W. Held and Mary E. Dodds
Program and Papers—Ralph R. Enghouser
Publicity—Edward W. Hidgetts
Registration and Reception—J. A. Kristof
Albert H. Clarke, Chairman of Central New York Chapter
Frank E. Mueller, Chairman of Cleveland Section
Ivar H. Stockel, Chairman of Michigan Section
H. E. Carney, Chairman of Northwestern Ohio Chapter
Robert W. Brown, Chairman of Ohio Valley Section
E. G. Zdenek, Chairman of Rochester Chapter
Harold P. Earley, Chairman of Western Michigan Chapter
W. B. Campbell, Chairman of Western Michigan Chapter

I.E.S. Mine Lighting Committee Holds Three-Day Conference

The first meeting of the recently appointed I.E.S. Committee on Mine Lighting developed into an important three-day conference held in Birmingham, Alabama, late in May. Several mines were inspected by members of the committee, during the meeting, and plans laid for future studies to be included in the committee's program. Mines inspected included the coal mine of the Alabama Power and Light Co., and an iron ore mine and coal mine of the Tennessee Coal, Iron and Railroad Co.

G. F. Prideaux, Chairman of the Committee, directed the meeting. Three projects set up for study are studies on visibility levels encountered in mines, headed by A. A. Eastman, General Electric Company; methods and materials for whitening mine interiors under E. J. Gleim, Bureau of Mines; and the development of permissible mine lighting equipment under the direction of W. H. Kahler, Westinghouse Electric Corp.

I.E.S. MINE Lighting Committee met for three-day conference in Birmingham, Alabama recently. In addition to committee members, a number of interested representatives of U. S. Bureau of Mines and manufacturers of mine equipment attended.

Milwaukee Section Active In Inter-Society Cooperation

The Milwaukee Section, I.E.S., has sponsored two programs to interest other technical organizations in educational efforts in planned lighting.

One, a series of six meeting, was prepared for architectural designers and consultants. The program, presented by members of the Section under the direction of the Educational Committee Chairman, I. L. Illing, covered:

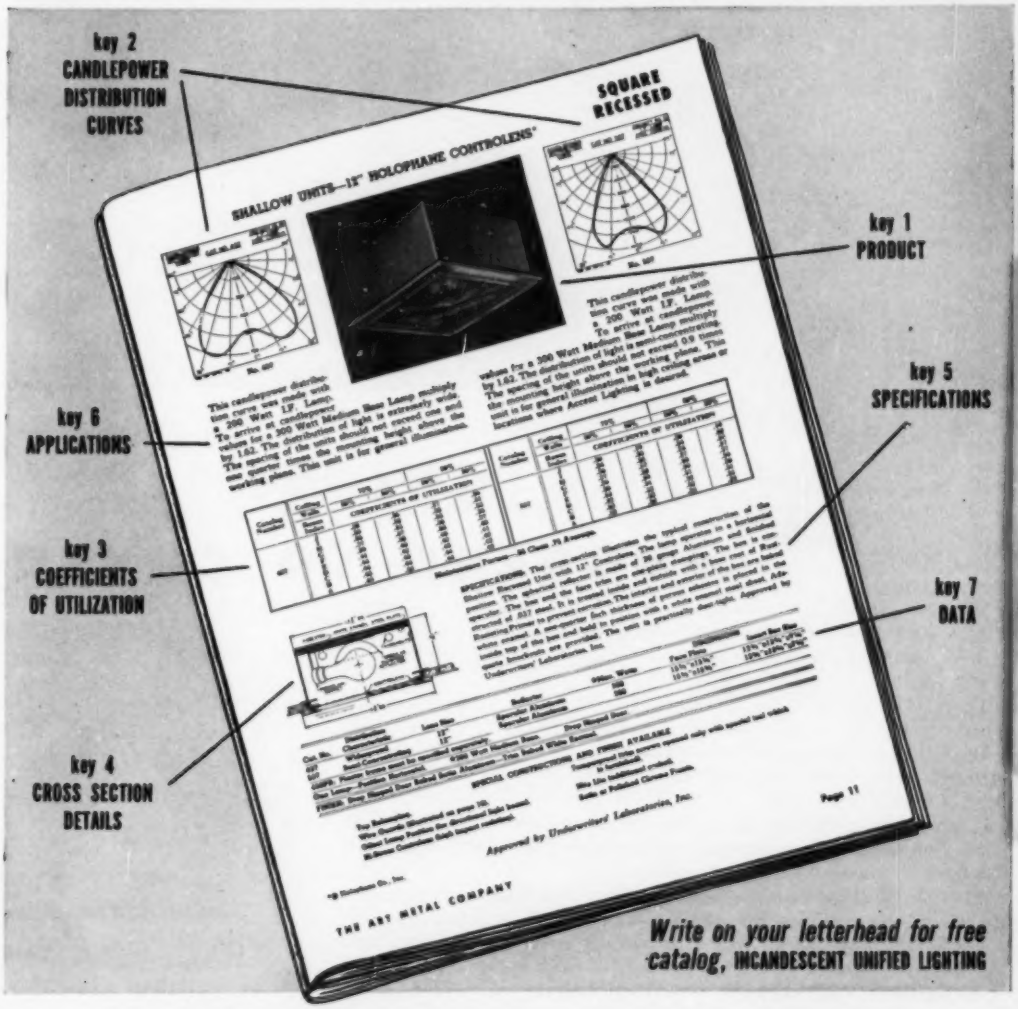
Light Sources of Today
Factors in Lighting Design
Lighting for Seeing (Schools—Offices)
Lighting for Selling (Stores, Show Windows, Display Areas)
Residential Lighting Application
Lighting for Recreation
Public Buildings—Churches

Attendance averaged 24 per session and a survey made following the program showed enthusiasm for continuing the series. Another program sponsored by the Section was a one-day session on industrial lighting and its role in the mobilization for defense. The meeting, held May 25, was planned for plant engineers, maintenance engineers, electrical contractors, safety directors, jobber and manufacturer's representatives. Fourteen national and local organizations were invited to attend. Subjects and speakers were:

Let's Look at Light Sources of Today — by Carl Jensen, Westinghouse Electric Co.

(*Continued on page* 13A)

7 KEYS provided by ART METAL to speed specification writing and installation planning for all types of INCANDESCENT LIGHTING



Write on your letterhead for free catalog, INCANDESCENT UNIFIED LIGHTING

THE ART METAL COMPANY • CLEVELAND 3, OHIO

Manufacturers of Unified Lighting Equipment for Office, Store, School, Hospital and Hotel

Art Metal Unified Lighting standardizes the design, style and finish of each unit, to achieve an architecturally integrated installation.

DRIVES MUGGERS TO COVER

Experience proves that crime shuns well-lighted streets. A Chief of Police in Iowa, said, of a new lighting installation in his city: "It has cut the crime in that area 90%."

Listen to a Chief of Police, in Tennessee—"... helped reduce the rate of murders and major crimes of violence 70 to 90%..."

Or the Chief of Police in a Texas community. "We have practically eliminated assaults, purse snatching, and robbery on three streets by relighting them."

Communities everywhere are finding that modern street lighting—besides cutting crime—attracts business, lowers accident rates, stabilizes property values—that it saves more than it costs.

Your electrical utility is keenly interested in your community's prosperity. They have the know-how and the experience to help you modernize your street lighting quickly on an economically sound, planned basis. They can call on General Electric's services for planning and consultation. G-E street lighting equipment has the flexibility to meet the specific needs of your community. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

Let your electric utility street lighting engineer show you how comfortable seeing SAVES YOU FAR MORE THAN IT COSTS

GENERAL ELECTRIC

952-107

(Continued from page 10A)

Tailoring Lighting to Production Methods—by E. A. Linsday, General Electric Co.
Offices Are Production Areas—Planned Lighting Works—by Wm. Wiebel, Curtis Lighting Co.
Inspection and Supplementary Lighting Systems—by R. Diefenthaler, General Electric Co.
Plant Protection—Carl Jensen, Westinghouse Electric Co.
Planned Lighting Aids Plant Safety—by M. F. Biancardi, Allis Chalmers Mfg. Co.

Dinner speaker was K. D. Flory, Assistant Director of Industrial Relations, Allis Chalmers Mfg. Co., who discussed "Civil Defense Aimed at Plant Protection."

Research Fund Grant Is Memorial to R. W. Staud

In memory of the late Rudolf W. Staud and in recognition of his many years of devoted service to the Illuminating Engineering Society, the Benjamin Electric Co., on its fiftieth anniversary, has made a contribution of $5,000 to the I.E.S. Research Fund. The grant is suggested for continuation of research in studies which will lead eventually to a true and accurate evaluation of the effect of illumination levels and the quality of illumination on visual fatigue.

MILITARY PROBLEMS in illumination were discussed at the regular meeting of the Coordinating Committee for National Defense of the I.E.S., held at the Engineer Research and Development Laboratories, Fort Belvoir, Va. Members conferred with representatives of the Corps of Engineers and other branches of the service on the current illuminating program. A description of the work being done by I.E.S. in connection with the defense effort is included in the article, "I.E.S. Research for Defense," by A. F. Wakefield, page 373 of this issue. Those attending included (left to right): Oscar P. Cleaver, Marshal N. Waterman, Lt. Com. John S. Walsh, L. B. Noffsinger, V. I. Ohman, LeVerne Johnson, Kenneth A. M. Smith, C. F. Cashell, C. L. Crouch, W. Finkelnburg, A. A. Anastasia, John A. Bartelt, A. F. Wakefield, Kirk M. Reid and Ernest Boghosian.

Design Competition Prizes Awarded By New York Section Residence Lighting Forum

Two top prizes and three honorable mentions were awarded to students of Decoration in Design in New York City, in the Design Competition conducted by the Residence Lighting Forum of the New York Section of I.E.S. Presentations were made by Miss Lucile Hanan, Chairman of the Forum, at a tea held June 5 at the Architectural League, New York City.

First prize of $50.00 was won by David L. Rowland, a Cranbrook Academy student, for his design "Lighting for Three." His entry displayed an understanding of the home lighting problems presented, and the lighting scheme he evolved was well designed to fit the character of the home and needs of the family.

Second place, $30.00, went to Joseph Paris of Whitman School.

Honorable mention was awarded to three other students, who were presented with copies of the book "Residential Lighting," by Myrtle Fahsbender. Honorable mention went to Joseph Johnson, Nicholas J. Minginourch and Raymond L. Lyons, Jr., all of Whitman School.

A modern functional feeling was achieved by the winner with his choice of fixtures and use of concealed and recessed lighting units. Valance lighting, under-cabinet strips, and recessed incandescent units are used in the kitchen and utility area. An eight-lamp brass chandelier from Finland House was selected for the dining room table, with valance lighting around three sides of the dining room. Modern floor lamps and a table lamp designed by Mr. Rowland are placed in the living area and den to provide supplementary light for reading. In both rooms, goosenecked spots are mounted on the walls over the sectional units. Valance lighting is extended down the length of the room over the windows, picking up the color of the draperies and giving both rooms a feeling of continuity. Recessed incandescent units for the terrace, and flood lights for the grounds mounted on the house eaves completed the plan.

The second prize winning plan followed the trend of modern design, using more ceiling mounted fixtures. Four ceiling fixtures using two twenty-watt fluorescent lamps each are mounted the length of the kitchen and laundry. Fluorescent strips mounted under the cabinets sup-

Tentative Regional Conference Dates

March 13-14, 1952	South Pacific Coast Region, San Francisco.
March 20-21, 1952	Pacific Northwest Region, Vancouver, B. C.
April 6-8, 1952	Southwestern Region, Tulsa, Okla.
April 20-22, 1952	Southern Region, Nashville, Tenn.
Apr. 30-May 2, 1952	Canadian Region, Hamilton, Ontario.
May 5-6, 1952	Great Lakes Region, Cleveland, Ohio.
May 22-23, 1952	East Central Region, Pittsburgh, Pa.
June 19-20, 1952	Northeastern Region, Swampscott, Mass.

plemented this lighting. Unique dining room lighting is provided by two hanging brass fixtures mounted on a recessed rail, allowing the fixtures to be spaced and located where they are needed. The same device is used in the living room with a swivel table lamp, and two bullet shaped spots mounted on the ceiling. Recessed fluorescent strip, flush with the ceiling and shielded by a frosted glass panel, is set over the draperies. A floor lamp in the den and two wall-mounted goosenecked spots are also provided for reading.

Details of the contest were arranged and conducted by the Design Competition Committee of the New York Section Residence Lighting Forum, under the direction of Thomas Smith Kelly. Judges were Myrtle Fahsbender, Director of Residence Lighting, Westinghouse Electric Corp., Berlon C. Cooper, Eastern Editor of *Electrical Construction and Maintenance*, Margaret Newman of T. S. Kelly Consulting Co., and Stanley McCandless of Century Lighting Inc.

Proceeds of the tea sponsored by the Forum have been earmarked for a similar competition to be sponsored next year.

Textile Lighting Committee Holds Meeting

The Textile Lighting Committee of I.E.S. invited Professors E. M. Strong and C. L. Cottrell of Cornell University and C. L. Crouch, Technical Director of the Society, to join them at a recent meeting to discuss the problem of measuring brightness values and visual requirements for various textile seeing tasks. The Cottrell contrast-brightness threshold meter (developed through an I.E.S. Research Fund sponsored project) was demonstrated, and committee members agreed that this is a helpful instrument for measuring relative visibility. Consistent values were obtained by the members of the committee who made readings on various details in weaving.

Mr. James Shute of Bachman-Uxbridge Worsted Corp. was host and provided excellent facilities under actual plant conditions for the Committee's study.

Members of the Textile Lighting Committee are Walter L. Kelley, Chairman; J. M. Shute, Vice-Chairman; F. J. Vorlander, Secretary; L. S. Cooke; L. A. Kline; Walter P. Rayner; F. E. Singleton and J. E. Watkins.

TEXTILE LIGHTING Committee members are guests of the Bachman-Uxbridge Worsted Corp. in studying visual requirements for textile seeing tasks. L. to r., Carl Rydman, L. S. Cooke, Prof. E. M. Strong, Prof. C. L. Cottrell, F. E. Singleton, Walter L. Kelley, F. J. Vorlander, Walter P. Rayner and C. L. Crouch watch a plant employee at his job.

A.L.P.A. "Centerline" Approach Lighting Installed at Newark Airport

On April 24 at Newark (N. J.) Airport, the first demonstration was made of the newly installed "centerline" airport approach lighting system. The "centerline" arrangement of approach lights has been advocated for some time by the Air Line Pilots Association. The Newark system, installed by C.A.A., is in accordance with latest A.L.P.A. recommendations.

Basically, this system has bar-shaped lights spaced on 100-foot centers along the extended centerline of the runway, reaching 3000 feet out into the approachway. Each "bar" light is approximately 15 feet long and one foot high, containing ten 250-watt PAR-56 all glass sealed-beam type lamps (same physical size as automobile headlamp); the "bars" are oriented transversely to the approachway axis. Larger transverse bars made up of several of the centerline bar lights are located at 200 feet and 1000 feet from the end of the runway. A high-intensity condenser discharge powered flashtube is located at each centerline fixture position.

The effectiveness of the A.L.P.A. system as well as that of slope line, the British Calverts' system and the French developed approach lighting system is to be appraised during the next year by an evaluation committee being set up by C.A.A. and other interested groups. The last three systems mentioned have recently been installed at the Naval Air Test Center, Patuxent, Md.

A centerline system, of appreciably different design, was included in the tests at the Landing Aids Experiment Station, Arcata, Calif., described in the paper "Recent Developments in Visual Low-Approach and Landing Aids for Aircraft," by Dr. Maurice A. Garbell, page 353, of this issue of ILLUMINATING ENGINEERING.

IT SEEMS TO ME

Series Ballasts

To the Editor:

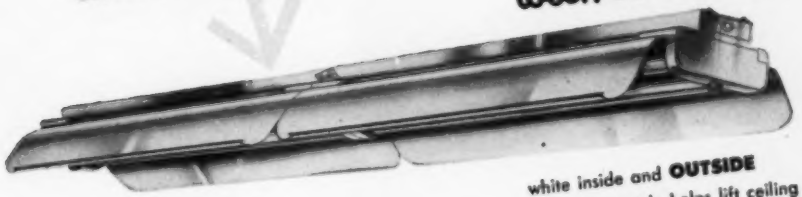
At the present time we are receiving complaints from many customers regarding short lamp life on T12 96" single pin lamps. The majority, but not all, of the fixtures concerned are wired with the new series ballasts. . . . We are having lamps darken on the end in one or two days and failures in 500 to 1,500 hours are quite common while numerous failures have occurred in considerably less than 500 hours.

(Continued on page 16A)

a new idea in factory lighting as different as white from black

it's all
Polar Bear White
for better sight
and better light

GUTH WYTE-LINER
with AIRFLOW channel



white inside and **OUTSIDE**
the white upside helps lift ceiling gloom
result: reduces strong shadows and harsh contrasts—no more gloomy "black-top" ceiling effects—improved brightness-contrast ratios—easier on the eye
surface 300° Permalux or Porcelain Enamel Airflow Channel circulates air for longer ballast life
easy to clean
easy to install
Wyte-Liners are made in 2 and 3 conventional 40-watt light units, also for 4- and 8-ft. Slimline lamps

may we send you our 16-page Wyte-Liner catalog 48-I with detailed information?

Guth LIGHTING
THE EDWIN F. GUTH COMPANY / ST. LOUIS 3, MISSOURI
Leaders in Lighting since 1902

(Continued from page 14A)

We do not sell lamps but are most interested in knowing just what we should rightly expect in the way of lamp life. For some time there was little agreement as to what effect series type ballasts would have on lamp life. Later, one of the major lamp manufacturers announced in print that two-thirds the normal lamp life could be expected if installed on series ballasts. Some of the major ballast manufacturers did not feel that this figure was entirely correct and seemed to think that the lamp life would not be shortened as much as one-third. During this same time one major lamp manufacturer started, and is continuing to advertise 7500 average lamp hours without further clarification. Other lamp manufacturers have been more hesitant to give a definite average life, however, 6000 hours seems to be pretty well agreed upon.

Now if 6000 is a correct average we should expect 4000 hours even with series ballasts. So far so good — if we were getting 4000 hours average I don't believe anyone would complain. But we are not, far from it.

We try to bring the lamp company representatives into this muddle and the first question they ask: "Is it series ballasts?" If it is they practically wash their hands of the matter. Upon being pushed further they have brought up the question of input voltage to the ballast and pointed to the label marked 118 volts. Now the latest alibi is that unless the input voltage is within 5%, plus or minus, of 118 volts they assume no responsibility regarding lamp life. This question of critical voltage has just been brought to our attention by the lamp companies and verified by various ballast manufacturers verbally after I have phoned them. To date we have not been very successful in getting either the ballast manufacturers or lamp companies to go on record as to just what we should expect in the way of lamp life if this all important (of late at least) 118 volts is not strictly adhered to.

Our position is one of uncertainty and we don't know what to do in this instance. We feel that if the series ballasts are as sorry as pointed out by the lamp companies they should never have been produced and sold in the first place and the excuse of meeting competition is a very poor one in our opinion. Furthermore, if the matter of voltage is so critical we feel that same should have been called to our attention more forcefully than the label on the ballast and in your specification sheets. I believe you will agree that 110-125 voltage range was considered OK for many years and although we noted the 118 volts on the label we did not understand it to mean 118 volts on the nose. We notice that one ballast manufacturer specifies an output voltage of, I believe, 750 volts now while a short time ago 625 was specified. Another ballast manufacturer is still specifying 625 volts output. If the input is so critical we fail to see why the output of the various manufacturers is not closer than 125 volts variation. We seriously doubt that many installations could be found where 118 volts was obtained at the fixture outlet.—MAX K. AULICK, *Orlando, Fla.*

Conference on Occupational Vision To Stress "Eyes for Defense"

A Conference on Occupational Vision is being called by Rutgers University for the purpose of promoting conservation of vision; protection of eyes against injury; and to aid in increasing the efficiency, health and welfare of workers in our industries. To be held in Atlantic City, November 1 and 2, 1951, the conference is sponsored by:

Extension Division, Rutgers University
New Jersey Optometric Association
New Jersey State Department of Labor
New Jersey State Department of Health
New Jersey Society of Safety Engineers
Illuminating Engineering Society
National Society for the Prevention of Blindness
New Jersey Society of Industrial Physicians
Industrial Nurses Association of New Jersey
New Jersey Society of Professional Engineers
New Jersey Society of Ophthalmology
Edison Electric Institute

Requests for further information should be addressed to Maurice A. Chaffee, Director, University Extension Division, Rutgers University, New Brunswick, N. J.

Co-ordinated Classroom Fellowship Established at Stanford

The Division of School Plant Planning of the School of Education, Stanford University, has announced the establishment of a fellowship to be called the "Co-ordinated Classroom Fellowship."

It is for the study of the effects of physical factors in the classroom upon the development, health and learning of school children. Particular emphasis will be on the study of effects of lighting, decoration, heating, and equipment on growing children.

The fellowship was made possible through grants from American Structural Products Co., American Seating Co., Minneapolis-Honeywell Regulator Co., National Chemical and Manufacturing Co., Pittsburgh Corning Corp., F. W. Wakefield Brass Co. and the Weber Costello Co.

The fellowship is to be used in connection with a program which the Division now has under way jointly with Dr. Darrell B. Harmon of Austin, Texas, educational consultant. The program and fellowship will be under the direction of Dr. James D. MacConnell, Associate Dean of the School of Education.

LIGHT SOURCES and Sorcery was a popular feature of the East Penn Science Congress, conducted recently at the Liberty High School, Bethlehem, Pa. Lighting educational talks and demonstrations were put on three times a day before some 1800 students by Paul Hildebrand (left) representing the Pennsylvania Power and Light Co. In the above photo, two Home Ec. students are "cooking with light" demonstrating new infrared lamp.

OBITUARY

Edward H. Hobbie, Member Emeritus of the Illuminating Engineering Society, died recently, after thirty years service to the lighting field. Mr. Hobbie joined the Society in 1916 and in 1920 was raised to Member grade. He was Secretary of the Society for two years, member of the Daylighting Committee for several years and served as Chairman of that committee. He pioneered in many of the surveys of glass for daylighting.

In 1950, upon his retirement from the Mississippi Glass Company, in recognition of his many contributions to the Society, Mr. Hobbie was elected to the status of Member Emeritus.

BOOKS AND PAMPHLETS

Interior Design Data, Bulletin L-T-10, is the most recent of the illumination bulletins distributed by the Northern Electric Corp. of Montreal. The bulletin contains pertinent information required for the design of lighting installations for industrial and commercial applications. Sample color chips with reflection factors are shown for typical interior paint colors. Included also are illustrations together with technical data of 68 specific lighting units, including distribution curves, height spacing ratios, maintenance factors, efficiencies and coefficient of utilization tables. Two pages are devoted to incandescent and fluorescent lamp data and one page to a list of current literature on lighting applications available from the Illuminating Engineering Society. Bulletin L-T-10 may be obtained on request from the Northern Electric Co., Ltd., Dept. 65, 1600 Notre Dame St. West, Montreal, Quebec.

A Lighting Guide to Better Drafting has just been produced by the Lamp Department of General Electric Co. with the theme "Production for national mobilization begins in the drafting room." The guide has many drawings and photographs illustrating proper lighting for straight-edges and shiny surfaces, positioning of drafting boards and recommended types of lighting system. R. L. Oetting, of General Electric is author of the booklet which can be obtained from the Inquiry Bureau of the company at Nela Park.

Industrial lighting booklet B-4727, is aimed at the industrial plant operator, stressing ways in which better lighting can cut production costs, increase efficiency and reduce accidents. The 16-page booklet analyzes fluorescent, mercury vapor and incandescent types of lighting as to efficiency, lamp life, maintenance. Copies of booklet B-4727 can be obtained from Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Supplementary Lighting for the Co-ordinated Classroom, a 20-page 8½ x 11-inch brochure, by Dr. Darrell B. Harmon and T. D. Wakefield, translates the findings of the authors into lighting equipment which meets the standards of the Harmon co-ordinated classroom. The conclusions are that classroom lighting must provide for distribution of light which permits the child to orient at almost any position in the room and to find the quantity and quality of light appropriate for recognition of the task and free performance of it.

Ninety-nine new and revised American Standards are listed for the first time in the latest edition of the **Price List of American Standards** just published by ASA. This complete listing of more than 1180 standard specifications can be obtained free of charge from the American Standards Association, 70 E. 45th Street, New York 17, N. Y.

Color Is How You Light It, a simplified lighting guide for commercial and home decoration, has been announced by Sylvania Electric Products Inc. The booklet analyzes the appearance of 40 popular colors under the eight white light sources now available It also suggests both first and second choice of light source for each color sample. The lighting guide is available from the company's Advertising Department, 87 Union Street, Salem, Mass. at 50c a copy.

Installations to See When You Visit Washington, D. C.

Installation	Address	Interesting Feature
Capitol Dome	Capitol Hill	Floodlighting
Capitol Plaza Fountain	Capitol Plaza	Mobile Color Lighting
Acacia Insurance Bldg.	2nd & Louisiana Ave., NW	Floodlighting
Government Printing Office	N. Capitol & H St., NW	Color & light conditioning
General Accounting Office	4th & H Sts., NW	Luminous indirect fluorescent
Federal Bureau of Investigation	10th & Penna. Ave., NW	Finger-print file section Indirect fluorescent
National Catholic Conference Building	1320 Mass. Ave., NW	Floodlighting
Loft Candy Store	1207 F St., NW	Luminous ceiling—atmosphere
Neisner's	12th & G Sts., NW	Color & high intensity
Robert Winston Candies	13th & G Sts.,NW	Louverall ceiling
Pohanka Auto Co.	1126 20th St., NW	Louverall ceiling—spots
Pan-American Union	18th & Constitution Ave., NW	Prismatic Lens—fluorescent
Biggs & Kirchner, Electrical contractor-engineers	1227 N. Ivy St., Arlington, Va.	Drafting Room, Luminous plastic ceiling
Woodward & Lothrop, Suburban Store	Wisc. Ave. at D.C. Line	Combination—flush fluorescent and incandescent
Giant Food Shopping Center	1753 Columbia Rd., NW	High intensity—Slimline

Compiled by Capital Section, I.E.S.

Election of New I.E.S. Officers

At a meeting of the Council held June 14, 1951, the report of the Committee of Tellers was presented, giving the results of the recent election of officers for the coming year, beginning October 1, 1951. The following have been elected to the offices indicated:

GENERAL OFFICERS

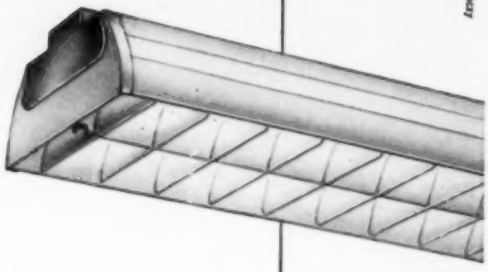
President — Samuel G. Hibben, Westinghouse Electric Corp., Bloomfield, N. J.

Vice-President — A. Homer Manwaring, Philadelphia Electric & Mfg. Co., Philadelphia, Pa.

General Secretary — Clarence C. Keller, Holophane Company, Inc., New York, N. Y.

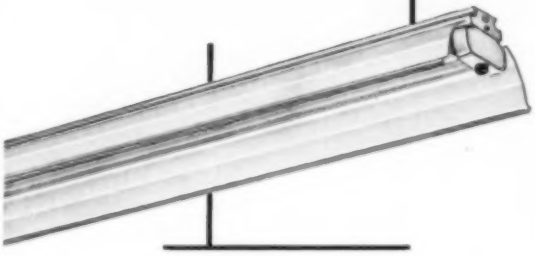
Treasurer — R. F. Hartenstein, Ohio Edison Co., Akron, Ohio.

(*Continued on page* 19A)



Nordin & Rodney

ELEMENTS TO LOOK FOR IN MEASURING LIGHTING FIXTURE VALUES



First and foremost, QUALITY of equipment to assure good lighting performance and long service. Then, engineering features that simplify installation and keep down to a minimum the cost of maintenance. And—important economic consideration—low overall cost (cost of equipment, installation and maintenance). These constitute VALUE—lighting satisfaction. You'll find all these elements in Miller lighting equipment—Fluorescent, Incandescent, and Mercury-vapor—built on an 8-Point QUALITY standard, on a background of 107 years' pioneering and progress in GOOD LIGHTING. Proven by thousands of installations in stores, offices, schools, factories and public buildings, covering a wide range of lighting requirements. Light with confidence the *proven* Miller way. Miller field engineers and distributors are conveniently located for nation-wide service.

THE miller COMPANY MERIDEN, CONN.
SINCE 1844

ILLUMINATING DIVISION: Fluorescent, Incandescent, Mercury Lighting Equipment
HEATING PRODUCTS DIVISION: Domestic Oil Burners and Liquid Fuel Devices
ROLLING MILL DIVISION: Phosphor Bronze and Brass in Sheets, Strips and Rolls

(*Continued from page* 17A)

Directors—(Until 1952) Rudolph E. Biesele, Jr., 3241 Amherst St., Dallas, Texas, and Duncan M. Jones, Curtis Lighting Co. of Canada Ltd., Montreal, Que. Canada; (until 1953) Roy A. Palmer, Duke Power Company, Charlotte, N. C. and L. A. Hobbs, Smoot-Holman Co., Inglewood, Calif.; (until 1954) G. W. Beals, The Miller Company, Meriden, Conn. and J. S. Schuchert, Duquesne Light Co., Pittsburgh, Pa.

Regional Vice-Presidents—Canadian Region F. P. Labey, Northern Electric Co., Montreal, Que. (appointed by Council to replace D. C. Borden, who was unable to accept the position); Southwestern Region — W. E. Folsom, Dallas Power & Light Co., Dallas, Texas; East Central Region — Paul H. Hildebrand, Penna. Power & Light Co., Allentown, Pa.; Southern Region — R. Cecil Paslay, Louisiana Power & Light Co., New Orleans, La.

British Columbia Section

Chairman — H. J. Ashbee, Amalgamated Electric Corp., Ltd., Vancouver, B. C. Secretary—R. W. Racine, British Columbia Electric Co. Ltd., Vancouver, B. C. Board of Managers—D. S. Gordon, A. A. Jones, W. J. Lind, F. S. Pettet, E. W. Thompson.

Capital Section

Chairman—R. P. Teele, National Bureau of Standards, Washington, D. C. Vice-Chairman—Carl G. Estabrook, Biggs & Kirchner Inc., Washington, D. C. Secretary—Claude R. Engle, Jr., General Engineering Associates, Washington, D. C. Board of Managers — George W. Clark, Noyce L. Griffin, Joseph C. Melton, Dorothy Nickerson.

Chicago Section

Chairman—R. R. Lusk, Commonwealth Edison Co., Chicago, Ill. Vice-Chairman—W. A. Weibel, Curtis Lighting Inc., Chicago, Ill. Secretary—J. R. Chambers, Benjamin Electric Mfg. Co., Des Plaines, Ill. Board of Managers —C. A. Basedow, C. K. Lambka, W. K. LeBold, C. B. Pederson.

Cleveland Section

Chairman—R. N. Green, The Wagner Green Co., Cleveland, Ohio. Secretary—W. S. Kolb, Westinghouse Electric Corp., Cleveland, Ohio. Board of Managers—L. J. Cahill, F. L. Detwiler, J. J. Neidhart, W. C. Schultz, K. A. Staley.

Connecticut Section

Chairman — Charles W. McCormick, The Connecticut Light & Power Co., Waterbury, Conn. Vice-Chairman—Francis Clark, Lighting Services, Waterbury, Conn. Secretary-Treasurer—Edward R. Cole, Hartford Electric Light Co., Hartford, Conn. Board of Managers—Frank E. Brown, Jr., John F. Dougherty, R. M. Hendricks, Raymond O. Mills.

Georgia Section

Chairman—T. Taylor Peake, Georgia Power Co., Atlanta, Ga. Vice-Chairman—J. Dixon Mitchell, Jr., Westinghouse Electric Corp., Chamblee, Ga. Secretary-Treasurer—Robert J. Kunell, Bob Kunell & Co., Atlanta, Ga. Board of Managers—H. R. Cahppell, H. M. Horton, Judd Lough, T. A. Willis.

Heart of America Section

Chairman—Frank I. Feagans, Kansas City Power & Light Co., Kansas City, Mo. Vice-Chairman—Carl N. Stover, Stover-Andrews & Co., Kansas City, Mo. Secretary—J. Gordon McDonald, Graybar Electric Co. Inc., Kansas City, Mo. Board of Managers—J. A. Ekstrom, Francis E. Miles, Glen E. Razak, Frank L. Taylor.

Iowa Section

Chairman — Chester P. Stone, Blackhawk Electric Co., Waterloo, Iowa. Vice-Chairman—James H. Hull, Geo. C. Mittauer & Associates, Des Moines, Iowa. Secretary—H. P. Wilson, Electrical Institute of the Tri-Cities, Rock Island, Ill. Board of Managers—W. D. Barnhizer, C. O. Christensen, George D. Hanaman, Fenn C. Horton.

Michigan Section

Chairman—Alfred C. Sangster, Detroit Edison Co., Detroit, Mich. Secretary—John E. Dawson, 12698 Greenlawn Ave., Detroit, Mich. Board of Managers—Earl R. Demoney, Paul H. Goodell, Allen J. Martin, John T. Parks, Harold C. Smith.

Milwaukee Section

Chairman—Earl H. Alk, 5816 W. Washington Blvd., Milwaukee, Wis. Vice-Chairman, Walter MacCue. Secretary-Treasurer—Benjamin F. Avery, General Electric Co., Milwaukee, Wis. Board of Managers — E. L. Hanley, Charles N. Laupp, William Lisch, John Peterson.

Montreal Section

Chairman — R. E. Hendershot, Canadian Westinghouse Co. Ltd., Montreal, Que. Secretary — R. H. Smith, Northern Electric Co. Ltd., Montreal, Que. Board of Managers—M. A. Decarie, B. C. Doucet, K. R. Jeffrey, Philip Richardson, R. S. Tate.

New England Section

Chairman—F. J. Verlander, Jr., Champion Lamp Works, Lynn, Mass. Secretary—W. E. Schwanhausser, Jr., General Electric Co., West Lynn, Mass. Board of Managers—L. S. Cooke, C. J. Kelleher, H. A. Klopot, W. K. Lewellen, J. J. Reddington.

New Orleans Section

Chairman—R. C. Paslay, Louisiana Power & Light Co., New Orleans, La. Vice-Chairman — Harbert S. Gregory, Gregory-Salisbury & Co., New Orleans, La. Secretary-Treasurer—Harry T. Bailey, Jr., Louisiana Power & Light Co., New Orleans, La. Board of Managers—S. C. Berdon, E. C. Guillot, Jr., A. A. Levy, John F. Morton.

New York Section

Chairman—E. H. Salter, Electrical Testing Laboratories Inc., New York, N. Y. Vice-Chairman — Alex Sitkin, Voorhees Walker Foley & Smith, New York, N. Y. Secretary—Marshall N. Waterman, Westinghouse Electric Corp., Bloomfield, N. J. Board of Managers—Arthur H. Brooks, Henry Chippendale, Jr., R. R. Marvin, Gene G. Rae.

(*Continued on page* 20A)

To the members of the Illuminating Engineering Society —

NEVER IN THE HISTORY OF THE SOCIETY have there been as many technical papers offered as this year for the Annual Conference. The Papers Committee has carefully screened all of this material and has prepared a most worthwhile well-balanced program, with seven half-day periods, four of which will have parallel sessions. Also, one evening will be devoted to the lighting program report and another evening to a program sponsored by the Coordinating Committee on Defense.

In order to keep pace with the progress and developments in illuminating engineering in many fields of application you cannot afford to miss the opportunity of listening to the presentations and discussions at the Shoreham Hotel Conference in Washington, D. C., August 27 to 30. In addition, you will meet your friends and associates in the lighting business with whom you can exchange lighting ideas and experiences to add to your professional knowledge. While in Washington you should plan to see some of the outstanding lighting installations such as those in the National Art Gallery and in the Capitol building.

The many historical exhibits, and attractive surroundings draw thousands of families to Washington each year and your family should join the group. Be sure to bring them and if it best fits your plans make the I.E.S. Technical Conference a vacation trip.

WALTER STURROCK, *President.*

June 4, 1951

(Continued from page 19A)

NORTHERN CALIFORNIA SECTION

Chairman—Stanton M. Blacksmith, Pacific Gas & Electric Co., Oakland, Calif. Vice-Chairman—Robert W. Thunen, Sylvania Electric Products Inc., Emeryville, Calif. Secretary-Treasurer—Beth McCrone, Chas. A. Von Bergen, San Francisco, Calif. Board of Managers—James E. Barnes, Sol Cohn, Dan M. Finch, William R. Major.

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Chairman—G. H. Seiter, Cincinnati Gas & Electric Co., Cincinnati, Ohio. Vice-Chairman R. J. Schulte, General Electric Co., Cincinnati, Ohio. Secretary—Edward J. McGinnis, Cincinnati Electrical Association, Cincinnati, Ohio. Board of Managers—Beattie M. DeLong, Theodore F. Keister, John B. O'Donnell, Paul W. Schath.

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Chairman—Nelson C. Warner, Westinghouse Electric Corp., Pittsburgh, Pa. Vice-Chairman—Gordon H. Maize, Duquesne Light Co., Pittsburgh, Pa. Secretary—John B. Rhea, West Penn Power Co., Pittsburgh, Pa. Board of Managers—Corydon M. Cryster, Hugh S. James, Carl J. Long, Harold D. Siler.

PUGET SOUND SECTION

Chairman—Byron G. Lind, City Light Dept., Seattle, Wash. Vice-Chairman—Freeman C. Scharr, 441 Dexter Horton Bldg., Seattle, Wash. Secretary-Treasurer—G. D. King, Puget Sound Power & Light Co., Seattle, Wash. Board of Managers—George Cooley, Frederick E. Cooper, H. A. Gardner, C. A. Scheyer.

ROCKY MOUNTAIN SECTION

Chairman—G. B. Buck, II, Public Service Co. of Colorado, Denver, Colo. Vice-Chairman—Ferman Bischofberger, Public Service Co. of Colorado, Denver, Colo. Secretary-Treasurer—Arthur F. Weers, Weers Electrical Planning Service, Denver, Colo. Board of Managers—Richard L. Haney, R. N. Hankins, William B. Petch, Carl Strain.

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Chairman—John J. Rhoades, City Sales Inc., St. Louis, Mo. Secretary-Treasurer—Leland M. Wallace, Jr., Westinghouse Electric Corp., St. Louis, Mo. Board of Managers—E. L. Ehret, Edwin H. Lauth, Carter Lewis, William Simms, Fred Walter.

SAN JACINTO SECTION

Chairman—George S. Trotter, General Electric Co., Houston, Texas. Vice-Chairman—Marcus L. Kennard, Gulf Coast Electric Supply Co., Houston, Texas. Secretary—E. C. Ober, Houston Lighting & Power Co., Houston, Texas. Board of Managers—H. W. Nussbaum, C. L. Osborn, Norval O. Reed, Warren Williamson.

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Chairman—James T. Maletio, Maletio Electrical Supply Co., Dallas, Texas. Vice-Chairman—Bernard F. Benning, Graybar Electric Co. Inc., Dallas, Texas. Secretary—W. T. Kimery, Dallas Power & Light Co., Dallas, Texas. Board of Managers—James N. Brannan, C. M. Cockrell, Jr., Theodore C. Lauck, William F. Owens, Jr.

TORONTO SECTION

Chairman—J. A. I. Kidd, Canadian General Electric Co., Toronto, Ont. Secretary—E. L. Dodington, University of Toronto, Dept. of Applied Physics, Toronto, Ont. Board of Managers—F. E. Barker, N. B. Chadwick, G. E. Davidson, W. F. C. Nottelman, A. H. Tackey.

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WESTERN NEW YORK SECTION

Chairman—Neal Jacobus, Sylvania Electric Products Inc., Buffalo, N. Y. Vice-Chairman—Walter H. Sherry, 1370 Main St., Buffalo, N. Y. Secretary—George Reinagel, Reinagel Lighting Co., Buffalo, N. Y. Board of Managers—John B. Gottardi, Russell S. Bucher, William B. Campbell, P. Paul Dewes.

NEW MEMBERS

At the meeting of the Council Executive Committee held in New York City on June 14, 1951, the following were elected to membership:

BALTIMORE CHAPTER

Associate Member:
Watson J. P., Westinghouse Electric Supply Co., Baltimore, Md.

BRITISH COLUMBIA SECTION

Member:
Hurley, A. M., Canadian General Electric Co., Ltd., Vancouver, B. C.

Associate Members:
Kolbeins, E. N., A. E. Simpson, Vancouver, B. C.
Powell, W., Canadian Westinghouse Co., Ltd., Vancouver, B. C.

CAROLINAS CHAPTER

Member:
Ellis, P. H., Noland Co., Inc., Winston Salem, N. C.

CHICAGO SECTION

Associate Members:
Arntzen, C. W., Arntzen Electric Co., Chicago, Ill.
Bonvallet, Gordon, Illinois Power Co., Decatur, Ill.
Bourscheidt, N. A., Bourscheidt Electric Co., Peoria, Ill.
Conrad, R. M., Jr., Beling Engineering Consultants, Peoria, Ill.
Kamlager, H. A., Kamlager Electric, Canton, Ill.
Kropp, H. W., Ferris & Kropp, Chicago, Ill.
Lyle, E. F., Keifer Electrical Supply Co., Peoria, Ill.
Pawson, R. C., Schertz Electric Co., Miner, Ill.
Pelz, C. B., Garden City Plating & Mfg. Co., Chicago, Ill.
Rahe, R. H., Westinghouse Electric Supply Co., Peoria, Ill.
Regan, J. W., St. Francis Hospital, Peoria, Ill.
Ringness, G. D., Jr., Foremost Electric Co., Peoria, Ill.
Unnewehr, L. E., Valparaiso University, Valparaiso, Ind.
Yee, M. S., Wright City Jr. College, Chicago, Ill.
Zurawski, E. F., Garden City Plating & Mfg. Co., Chicago, Ill.

Student Member:
Mescher, W. C., University of Illinois, Urbana, Ill.

CLEVELAND SECTION

Member:
Horton, G. A., Westinghouse Electric Corp., Cleveland, Ohio.

Associate Members:
Ake, Theodore, Jr., Cleveland Electric Illuminating Co., Cleveland, Ohio.
Kraut, A. S., Leff Electric Co., Cleveland, Ohio.

Student Members:
Emerick, C. A., Case Institute of Technology, Cleveland, Ohio.
Eppele, K. R., Case Institute of Technology, Cleveland, Ohio.
Flickinger, N. R., Case Institute of Technology, Cleveland, Ohio.
Gandal, M. B., Case Institute of Technology, Cleveland, Ohio.
Greenwood, R. E., Case Institute of Technology, Cleveland, Ohio.
Homer, E. P., Case Institute of Technology, Cleveland, Ohio.
Jakobowski, Walter, Case Institute of Technology, Cleveland, Ohio.

CONNECTICUT SECTION

Associate Members:
Fitzgibbon, J. A., Sylvania Electric Products, Inc., Boston, Mass.
Kelly, H. S., 282 York St., New Haven, Conn.
Timoshenko, Gregory, University of Connecticut, Storrs, Conn.
Valentine, C. E., Sylvania Electric Products, Inc., Boston, Mass.

EASTERN PENNSYLVANIA CHAPTER

Associate Members:
Barton, G. H., Jno. Z. Barton, York, Pa.
Fite, J. T., Jr., Graybar Electric Co., Inc., Harrisburg, Pa.
Gernerd, H. W., Gilbert Associates, Inc., Reading, Pa.
Hauler, T. B., General Electric Supply Corp., Reading, Pa.
Reesta, S. J., Bright Sign Service, Reading, Pa.
Stehly, C. G., Neon Sign Plant, Bethlehem, Pa.

FLORIDA CHAPTER

Associate Member:
Hedrick, R. P., Jacaranda Hotel Bldg., Avon Park, Fla.

GEORGIA SECTION

Members:
Hannah, R. D., Georgia Power Co., Columbus, Ga.
McComack, J. E., Noland Co., Inc., Atlanta, Ga.

Associate Member:
Pollock, R. H., R. H. Pollock & Associates, Atlanta, Ga.

HEART OF AMERICA SECTION

Associate Members:
Johnston, E. E., Evans Electric Const. Co., Kansas City, Kans.
Meadows, C. R., Evans Electrical Const. Co., Kansas City, Kans.

INDIANA CHAPTER

Associate Member:
Strecker, C. E., General Electric Co., Ft. Wayne, Ind.

INLAND EMPIRE CHAPTER

Associate Member:
Harris, E. L., Flatiron Bldg., Pullman, Wash.

MEXICO CHAPTER

Associate Members:
Margain, M. L., Pitagoras 721, Mexico 12, D. F.
Paparelli Ugarte, Luis R., 16 de Septiembre 6-610, Mexico City, D. F.
Saenz de Cameara, Manuel, Illuminacion Planeada S. de R. L., Mexico D. F.

(Continued on page 31A)

The Wakefield Grenadier is a direct-indirect luminaire, sturdily built of heavy gauge steel, well louvered and shielded, with translucent plastic side panels. It provides an abundance of light, and is highly effective in giving sparkle to food and stimulating movement of students. It is especially useful in cafeterias, corridors and other similar areas.

The Grenadier is available in stem, canopy and on-ceiling models, for two or four bipin or slimline lamps, and may be installed in continuous runs or singly. It is easily installed (a one-man job!) and very economically maintained. For a booklet on the complete line of Wakefield Grenadiers, write to The F. W. Wakefield Brass Company, Vermilion, Ohio.

Basic for Co-ordinated Classrooms — the Wakefield luminous indirect luminaires

THE STAR (fluorescent) and THE COMMODORE (incandescent)

Wakefield Over-ALL Lighting

THE F. W. WAKEFIELD BRASS COMPANY • VERMILION, OHIO

Which kind of lighting costs less?

THE lighting at the left may look cheaper but it isn't. It doesn't give workers enough light for efficient seeing and it creates glare. Workers suffer eye strain and fatigue. The result is costly—in errors, lower worker efficiency, lagging production.

With G-E Fluorescent lamps in installations like the one at right, above, light is plentiful, cool, free from excessive glare. The trickiest seeing jobs are easier, go faster. There are fewer accidents and rejects, more production. That's the result when a plant has modern, planned lighting throughout—with the right lamps in the right fixtures in the right locations.

FREE BOOKLET! General Electric has recently prepared a new, illustrated bulletin, "Planned Lighting for Industry". It contains facts and figures that will help you create "better lighting for better production". For your free copy, write to General Electric, Lamp Division, Department 166-IE-7, Nela Park, Cleveland 12, O.

World's Most Modern Light Source

Newest form of fluorescent is G-E slimline—up to 8' in length. Its advantages:

1. New streamlined appearance
2. Instant start . . . no starters
3. Single pin base . . . easy to install
4. High efficiency
5. Lower upkeep—fewer replacements
6. Long dependable life

You can put your confidence in—

GENERAL ELECTRIC

NEW!

JOB-RATED LIGHTING FOR AMERICAN INDUSTRY

NOW—MITCHELL introduces the first Job-Rated lighting line designed to the specifications of American industry. "*Dynalite*" offers 82 high-efficiency units in an unprecedented range of types for *proper* lighting in every working area. Featuring exclusive new advantages, "*Dynalite*" makes possible simplified planning and installation of lighting rate, to provide maximum efficiency in any industrial application.

THE COMPLETE, UNIFORM, IN-STOCK INDUSTRIAL LIGHTING LINE

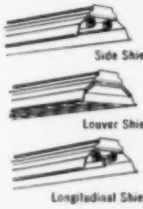
6 LAMP TYPES & SIZES

T-12 40-watt 48" bi-pin
T-17 40-watt 60" Low-Brightness mogul bi-pin
T-17 40-watt 60" Low-Brightness single pin
T-17 85-watt 60" Krypton mogul bi-pin
T-12 40-watt 48" 430 ma. Slimline
T-12 75-watt 96" 430 ma. Slimline

4 LAMPHOLDER TYPES

Medium Bi-Pin
Push Type Single Pin
Mogul Bi-Pin
Turret Type Bi-Pin

3 SHIELDING TYPES



Side Shielded
Louver Shielded
Longitudinal Shielded

2 REFLECTOR TYPES

MITCHELL Baked Enamel
RLM Porcelain Enamel

MULTI-CHANNEL TYPES—*THE RIGHT UNIT FOR EVERY JOB*

Available in 4, 5, 8 and 10 foot lengths . . . single, tandem and combination types . . . 2, 3 and 4 lamp units. Continuous uniform wireway channel makes it easy to plan any installation *light-rated to the job*. There's nothing like "*Dynalite*" for limitless flexibility, economy, quality and dependability.

Send for it **"DYNALITE" CATALOG**

See how MITCHELL "*Dynalite*" custom-fits any industrial lighting job. Have the complete technical data that makes it easy to specify *correct* industrial lighting. You'll want a FREE copy of the complete "*Dynalite*" Catalog packed with descriptive details. Write for it today.

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*Firm Name*_____

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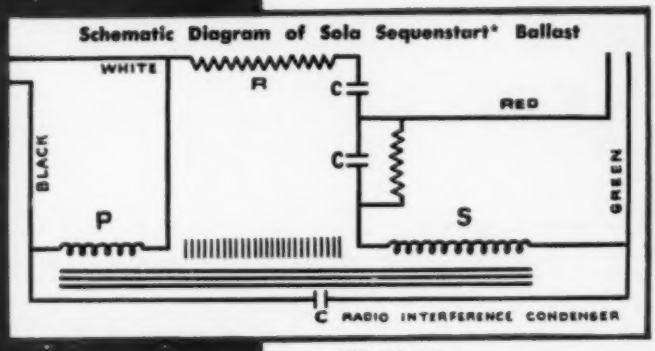
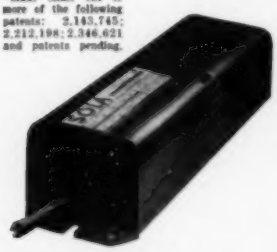
*City*_____ *Zone*____ *State*_____

more lumens per watt

only SOLA Ballasts have the original *Sequenstart* circuit design



*Made under one or more of the following patents: 2,143,745; 2,212,198; 2,346,621 and patents pending.



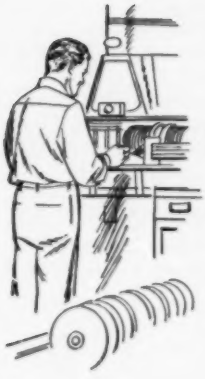
A folder listing electrical and mechanical specifications of SOLA Ballasts is available on request. Write for Bulletin C-PFL-144.

SOLA — THE ONLY FLUORESCENT BALLASTS WITH ALL THREE:
1) Constant Light Output 2) Cooler Operation 3) More Lumens per Watt

SOLA *Sequenstart* BALLASTS

*TRADEMARK

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois



Workers Can See What They're Doing In This Plant

Production men know that good factory lighting steps up production, cuts down spoilage, improves employee morale. But, to correct inadequate lighting, many plants merely increase the footcandles of light intensity—and think they've solved the problem. Actually, *too much* light . . . or glare from bare fixtures . . . can be as harmful as insufficient light. To get best results from plant and worker, light must be adequate *and* comfortable.

Day-Brite designs industrial lighting fixtures which give *both* adequate and comfortable light. In the Day-Brite lighted plant shown above, you can see clearly and without strain . . . without glare or shadows . . . in every part of the plant.

And — Day-Brite makes *only* quality fixtures which give years of trouble-free service . . . the lowest possible installation and maintenance costs. Proof? The hundreds of large American factories which use Day-Brite fixtures . . . and get complete satisfaction.

If *you* have factory lighting problems ask Day-Brite for help without obligation. Write to Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis, Mo.

**The upward component provided through the reflector apertures minimizes contrast between the fixture and the surrounding ceiling area, adding to the overall comfort of the complete installation.*

NOW, MORE THAN EVER

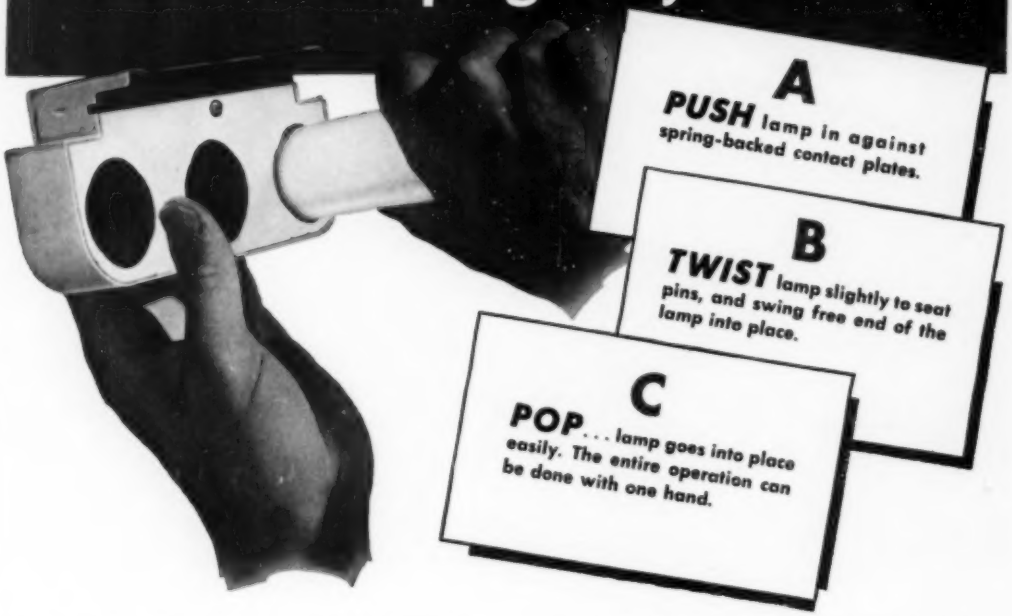
AMERICA MUST SEE WHAT IT'S DOING

IT'S EASY TO SEE WHEN IT'S

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

141

Make Re-lamping easy as A B C


A
PUSH lamp in against spring-backed contact plates.
B
TWIST lamp slightly to seat pins, and swing free end of the lamp into place.
C
POP . . . lamp goes into place easily. The entire operation can be done with one hand.

Here's the really fast and easy way to re-lamp fluorescent fixtures with one hand. General Electric Turret* lampholders make maintenance as easy as A B C—let maintenance men take out old lamps and install new ones in a matter of seconds.

G-E Turret lampholders reduce the hazard of falling lamps. The simple locking action of the Turrets holds lamps in place without springs or clips.

G-E Turrets are just as easy to install as they are to maintain because the lampholder and starter sockets are housed as one unit in tough sheet steel.

They can be mounted conveniently on any flat surface—and are suitable for back-to-back mounting in continuous lighting installations.

And, for time-saving wiring, G-E Turrets feature straight-line guide holes. Simply insert stripped, tinned leads, and clamp in place with terminal screws. That's all.

For simplicity of installation and maintenance, insist on G-E Turret lampholders. Call the Accessory Equipment specialist at your local G-E office for details. Or, write Section Q70-787, Construction Materials Department, General Electric Company, Bridgeport 2, Conn.

Watch Dog* Starters eliminate annoying flicker caused by failing lamps. Look for the red reset button.

Standard Starters. Glow-switch Type (voltage actuated) and Thermal Type (current actuated) cover the full range of fluorescent lamp requirements.

Standard lampholders and combination lampholders and starter sockets constitute a full line for most types of fluorescent fixtures.

Special lampholders including butt-on and waterproof types are all part of the G-E line.

*Registered Trade Mark of General Electric Company

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GENERAL ELECTRIC

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(See Page 4A)

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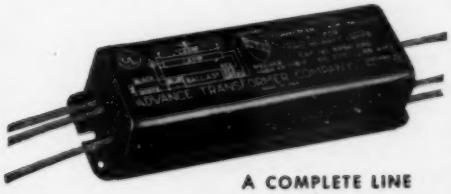

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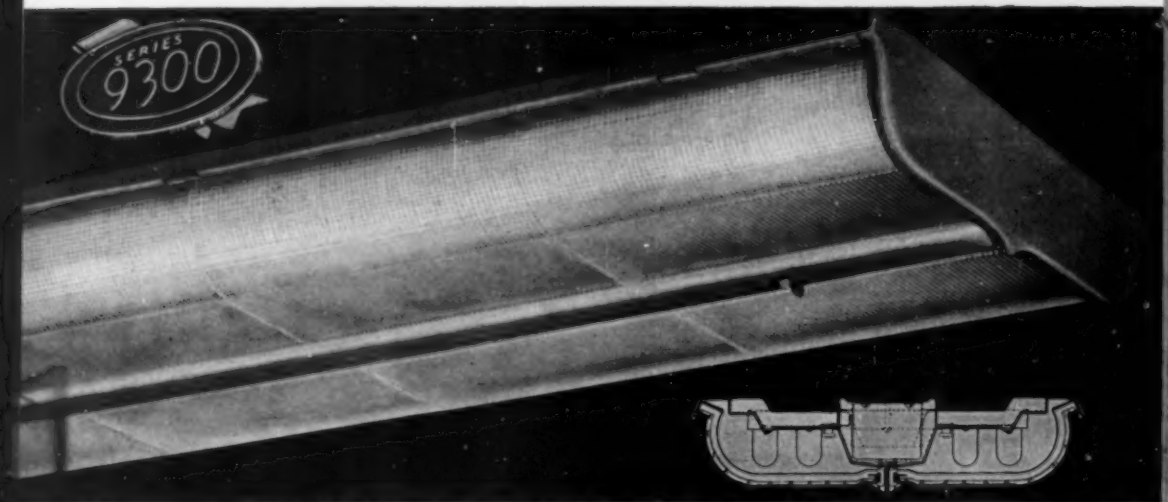

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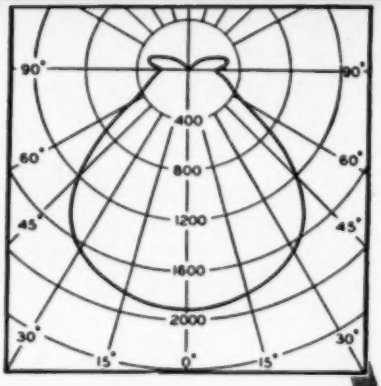

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- designed specifically to achieve low fixture-ceiling contrast ratios
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- wiring and ballasts maintained without removing plastic panels from fixture
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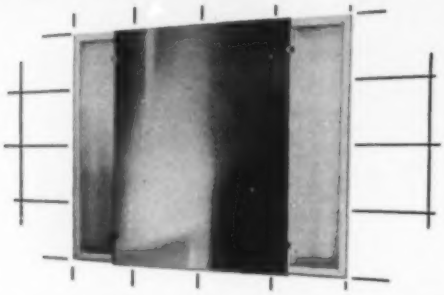

The only cabinet with *four* 20-watt lamps!

Now you can easily specify good lighting for the bathroom, too! The Milwaukee cabinet provides completely recessed lighting—for glareless, shadowless illumination. With *four* 20-watt fluorescent lamps, no other illumination is ordinarily needed in the bathroom. For all other facts on this most modern of bathroom cabinets, write for bulletin B-108. Or see your electrical wholesaler . . . today.

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Acme ACME Electric

INDEX TO ADVERTISERS
July 1951

Acme Electric Corp.	32A
Advance Transformer Co.	29A
Aerolux Light Corp.	34A
Art Metal Co.	11A
Benjamin Electric Mfg. Co.	Inside Front Cover
Certified Ballast Manufacturers	Inside Back Cover
Day-Brite Lighting Inc.	25A
General Electric Co., Apparatus	12A
General Electric Co., Const. Mat'ls.	26A
General Electric Co., Lamp	22A
Edwin F. Guth Co.	15A
Holophane Co. Inc.	30A
Litecontrol Corp.	2A
Miller Co.	18A
Mitchell Manufacturing Co.	23A
Northern Light Co.	32A
Sola Electric Co.	24A
Sunbeam Lighting Co.	31A
Thompson Electric Co.	34A
F. W. Wakefield Brass Co.	21A
Westinghouse Electric Corp., Lamps	Back Cover
Westinghouse Electric Corp., Lighting	1A

(*Continued from page* 31A)

Mutnick, Harry, Verd-A-Ray Corp., Rochester, N. Y.
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FOR THE BIRDS

BIRD: Stop shaking the pole! You'll scramble my eggs!

MAINTENANCE MAN: But, Mrs. Bird, it's my job to service this light!

Well, be smart and get a THOMPSON HANGER! Then you could lower the light to the ground for servicing. You'd be safer, the company would save a lot of money, and I'd have some peace.

Lower the light? Didn't know it was possible! How would I get it up again? And what about the wiring and electrical hazards?

The THOMPSON HANGER is simplicity itself. All up-and-down movement is controlled by a chain or cable that's part of the installation, and the live electrical contacts stay at the top. What's more, the hanger automatically repositions itself. It's completely safe and absolutely foolproof.

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Offers opportunity of many new fashions in home decorations and subdued lighting.

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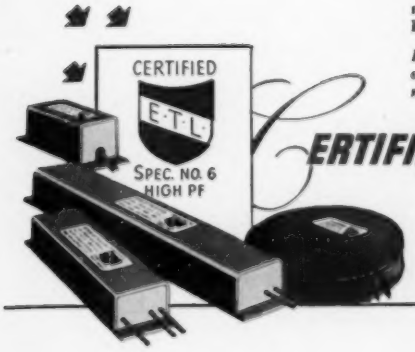
CERTIFIED BALLASTS are made to exacting specifications, then tested and checked by Electrical Testing Laboratories, Inc.

*Lead lamps on a two-lamp ballast.

● Complete information on the types of CERTIFIED BALLASTS available from each participating manufacturer may be obtained from Electrical Testing Laboratories, Inc., East End Avenue at 79th Street, New York, New York.

Participation in the CERTIFIED BALLAST program is open to any manufacturer who complies with the requirements of CERTIFIED BALLAST MANUFACTURERS.

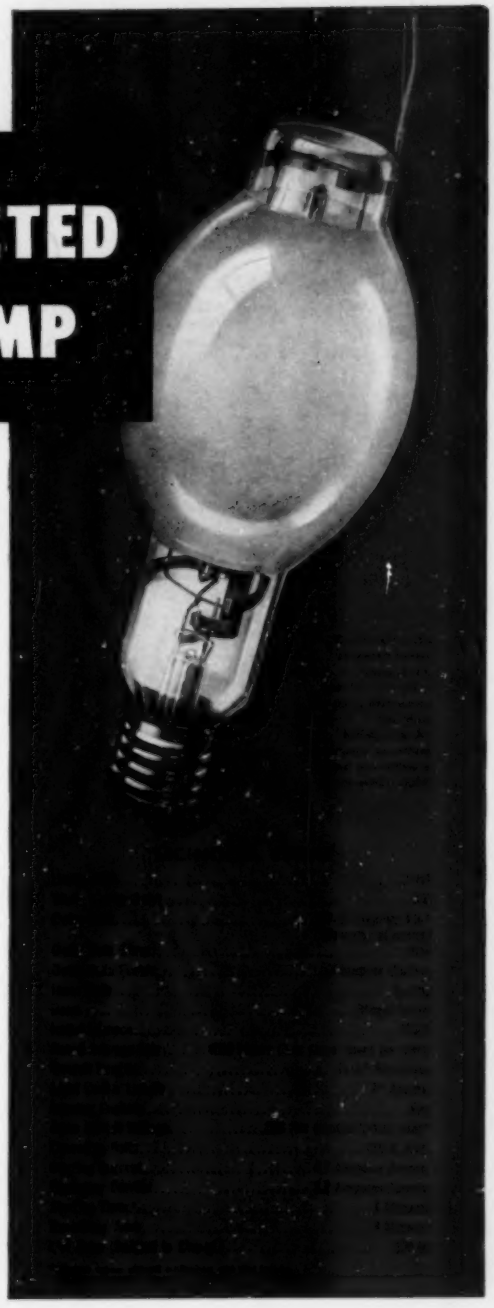


CERTIFIED BALLAST MANUFACTURERS

Makers of Certified Ballasts for Fluorescent Lighting

2116 KEITH BLDG., CLEVELAND 15, OHIO

COLOR-CORRECTED MERCURY LAMP



EXCLUSIVE WESTINGHOUSE DEVELOPMENT COMBINES HIGH EFFICIENCY WITH WARMER COLOR

A new type of mercury lamp that has the familiar mercury-lamp advantages of high output and high efficiency *and a warmer color than previous models*, is now available from Westinghouse.

This color-corrected lamp is rated 400 watts, 18000 lumens, and is called Type J-H1. Electrically, the lamp is like the 400-watt A-H1 and E-H1 types. It will operate from H-1 ballasts, burn in any position, and fit most 400-watt mercury fixtures.

A principal advantage of the new lamp is that its use will preclude the necessity for a large percentage of incandescent lamps which previously served to provide color correction. Consequently, the lamp should find considerable service for industrial lighting, floodlighting and street lighting.

At present, the lamp is available in limited quantities, primarily for trial installations. For more information about it, write the Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey.

YOU CAN BE SURE...IF IT'S Westinghouse